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Use of Electrostatically Charged Fog for Control of Fugitive Dust Emissions

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16. ABSTRACT The report gives results of tests of the use of electrostatically charged fog to control a wide variety of industrial pollutants, ranging from silica flour to SO2 and fly ash. It has been demonstrated that most industrial pollutants acquire an electrostatic charge as they are dispersed into the air. If this charged airborne material is exposed to an oppositely charged water fog there is enhanced contact between the particulates and the fog droplets. After contact is made, the wetted particulates agglomerate rapidly and fall out of the atmosphere. The tests showed that, in general, there has been significant suppression with a minimum of water fog. The technique is therefore well suited to control of moving or fugitive dust sources where the usual hooding and control systems cannot be applied.

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Notice: Much of the data given in this paper was reported at the 1976-1977 meetings of the American Industrial Hygiene Association. More recent results have been added as the data became available.

Disclaimer Statement

This report has been reviewed by Dr. Stuart A. Hoenig, and the Environmental Protection Agency (EPA), and has been approved for publication. Approval does not signify the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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Summary

We have demonstrated that most industrial pollutants acquire an electrostatic charge as they are dispersed into the air. If this charged, airborne material, is exposed to an oppositely charged water fog there is enhanced contact between the particulates and the fog droplets. After contact is made the wetted particulates agglomerate rapidly and fall out of the atmosphere.

This technique has been tested on a wide variety of industrial pollutants ranging from silica flour to sulfur dioxide and fly ash. In general, there has been significant suppression with a minimum of water fog. The system is therefore suited to control of moving or fugitive dust sources where the usual duct and baghouse systems are too costly or ineffective.

Conclusions

We suggest that charged fog has a significant potential for suppression of dust from open sources. This technique would be most suitable for control of fugitive dust that cannot be easily contained or captured by hoods.

The data further suggests that charged fog might be used ahead of an electrostatic precipitator, scrubber or bag filter to agglomerate fine particles and increase the efficiency of the dust control system.

Other studies have indicated that charged fog can be used to suppress fumes, i.e., SO_2 by inducing them to absorb on ambient dust particles. If this can be further substantiated it may proved an important weapon in the battle to clean up the environment.

Recommendations

We suggest that the present research program on the use of charged fog to suppress respirable dust be continued and expanded to a wider range of applications. Topics of particular interest might include:

1. Development of dust control systems for moving sources, i.e., lift trucks and in-plant vehicles;
2. Control systems for open field stackers which are impossible to hood and result in significant dust fallout;
3. Coke oven facilities that are significant polluters and very difficult to control by conventional means;
4. Smelters and power plants which produce both dust and SO_2. Here we would expect to induce the SO_2 to absorb on the dust before agglomeration occurs. Subsequent dust fallout or collection would remove both pollutants.

1. Introduction

Beginning in 1973 a number of studies were done at the University of Arizona to determine if electrostatic charging was a factor in the levitation of dust on Mars. No Mars dust samples were available and tests were run on a variety of industrial, and naturally occurring, particulate materials. The results indicated that in the great majority of cases the respirable materials (below eight micrometers in diameter) were charged and that the finer (one micrometer) particles were almost always charged negatively.

These results suggested that it might be possible to suppress industrial pollutants by exposing them to an oppositely charged water fog. The electrostatic effect would encourage fog-dust contact and the wetted particulates would be expected to agglomerate and fall out. There were several potential advantages to a system of this type.

1. The quantity of water involved would be very low thereby conserving water resources in the arid southwest. Limited water use would permit the application of fog on water sensitive materials, i.e., flour, cement, etc.
2. A system of this type would be suitable for control of moving dust sources, i.e., trucks, sweepers, front loaders, where conventional methods could not possibly be used.
3. Water fog agglomeration might be used to enhance the operation of electrostatic precipitators which are known to have reduced efficiency for fine (one micrometer) particulates.

If the particulates could be agglomerated ahead of the precipitator the system effectiveness would be greatly increased.

4. Many aerosols, i.e., SO_2, NO_x, NH_3 are water soluble and would be expected to interact with charged water fog. The droplets might absorb on ambient dust particles (that are in the process of agglomerating) thereby removing both the dust and the aerosol at the same time. Another mechanism might involve direct fog induced agglomeration of the smoke or aerosol. Once again the large drops would be expected to fall out quite rapidly.

II. Experimental Studies

The first investigation was aimed at a determination of the charge vs. size spectrum for typical industrial dusts, after grinding and dispersion into the air. The test materials, obtained from a variety of sources, were ground and dispersed by means of the arrastra mill shown in Figure 1. The powdered material was blown into a small dust tunnel, sampled and analyzed by a modified Anderson-2000 Company Impaction Sampler* (shown in Figure 3). Typical results in terms of charge** vs. particle size are shown in Figures 4 through 15; i.e.,

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*The sampler flow rate was 28.2 l/min., a sample run required some nine minutes.

**We recognised that it would be advantageous to have the charge data in absolute rather than relative units. However, a study of the literature, i.e., Loeb Ref 2ab and some laboratory tests indicated that the process would be difficult, time consuming and subject to severe error. In any case the important fact was that the dust was charged and that the respiratory material was predominately negative in sign. Constraints of time and funding precluded any further effort to measure absolute charge for the industrial materials of interest.

4 slate, 5 granite, 6 clay, 7 trap rock, 8 magnetite, 9 foundry dust, 10 shale, 11 fly ash, 12 copper concentrate, 13 cement quarry material, 14 cement clinker, and 15 silica sand. In view of the toxicity of silica dust, it was of interest to observe the decay of the silica charge as a function of time and particle size. The data is shown in Figure 16. It is apparent that the smallest respiratory material is most highly charged and decays quite slowly. This may be connected with the pathogenic effect of silica. Experimental studies of this question were reported in Reference 1.

The data of Figures 4 through 15 indicates that the respiratory-size material was always charged and that generally the charge was negative in sign. There have been a number of studies on the question of how and why dust charging occurs, i.e., Loeb (2a,b), Harper (3), Gallo and Lama (4). There is no general agreement but we prefer the theory of Gallo and Lama that predicts a negative charge on the smaller dust particles. In this connection it is important to note the effect of impurities as discussed by Loeb. His book indicates that when pure quartz is ground there are as many positive as negative particles, at every size level. When the quartz was contaminated with a metal (platinum) a predominance of negative charge was observed (2a, b). In this connection it is important to note that small dust particles are frequently contaminated with absorbed metals from vapors generated during combustion or melting (5). An effect of this type may be responsible for the results of Figures 4 through 15.

In any case, the above data suggests that under normal conditions respiratory dust will not agglomerate and fall out, because the uniformity of charge will reduce the number of particle collisions. Since most particles are negative and the earth's surface normally carries a negative charge (6), it appears that electrostatic levitation would further reduce the rate at which such particles fall out of the atmosphere.

Many attempts have been made to encourage dust agglomeration by wetting down the dust; however, the difficulties of generating a micron sized fog and inducing the fog to make contact with the dust particles has almost precluded the use of fogging to control open air dust problems. (Some closed dust control systems use electrostatic techniques to charge the dust. The charged particles are then sprayed with oppositely charged water which is effective in making contact with the dust. This method requires a closed vessel and the dust must be properly charged by induction or ion diffusion. The resultant system is complex and only suited for dust that has been captured by hoods and collectors (7)).

A. Generation of Charged Fog

We have made use of a modified commercial* electrostatic paint spray gun plus a University of Arizona designed apparatus** for generation of highly dispersed, micron sized, fog that carries a positive or

*Provided by the Ransburg Corporation of Indianapolis, Indiana.

**A commercial version of this system is marketed by the Ransburg Corporation.

negative charge, as desired. No clogging or deposits have been observed after many hours of operation, with untreated tap water.

Information on the droplet spectrum, generated by the fogging system, was not available from the manufacturer of the spray nozzles.* An evaluation of the droplet spectrum was done by collecting the drops on a microscope slide coated with MgO and measuring the spot diameters with a reticule in the microscope (8). There was a significant decrease in drop size with the charging voltage "on". We suggest this was due to electrostatically induced fracture of water droplets (9). The microscope data indicated that more than seventy five per cent of droplets were less than fifty micrometers in diameter.

Another experiment, designed to measure the electrostatic charge per droplet, made use of a fog gun and an electrically isolated metal dewar cooled by a mixture of dry ice and acetone. The fog condensed on the walls of the dewar and the resultant electrical current was measured by a picoammeter driving a chart recorder. Integration of the current versus time yielded the total charge delivered to the dewar. The dewar was weighed at the beginning and end of the experiment to determine the total quantity of fog condensed. Assuming that the average droplet size was some twenty five microns, the average number of elementary charges per droplet was found to be $8 \cdot 10^5$. This may be compared with the calculated data of reference 10 which indicates a maximum charge of some $6.5 \cdot 10^7$ elementary charges for this size droplet.

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*Spraying Systems Company, Wheaton, Illinois

We might note here that droplet charging was by induction and as the density of the spray cone increases there is a tendency for charging to be limited to the outside of the cone. Direct contact charging is more efficient but may lead to problems of electrical leakage back through the water line to the tank. This leakage may be limited by using long plastic tubes, of small diameter, to provide a high resistance path. We have found it more effective to deliver a mixture of air and water rather than a solid column of water to the nozzle. The air bubbles effectively block the electrical leakage (as long as plastic tubing is used) and we have found it possible to isolate voltages up to 20 kV by this technique.

B. Dust Tunnel Studies

The interaction between industrial dusts and charged fog was investigated in the dust tunnel shown in Figure 2. The charged fog and the dust were blown in at one end of the tunnel, and an industrial vacuum cleaner was used to extract the remaining dust at the other end. The Anderson Sampler was connected some two feet from the downstream end of the tunnel. Several attempts were made to measure the airflow in the tunnel so that sampling could be done isokinetically. Unfortunately the flow velocity in the tunnel varied from day to day as the vacuum cleaner bag loaded up so it was not practical to choose a fixed velocity for isokinetic sampling. The variations during a given run were not large enough to affect the data and the primary interest was in comparing the dust density with and without charged fog.

Typical results with this system, using foundry dust, are shown in Figure 17; without the fog, the dust level was quite high. There was some decrease in the dust level with uncharged fog, but with positively charged fog the decrease was dramatic. (The choice of positively charged fog was made on the basis of Figure 9 that indicated the respirable material was (-) in sign.)

Other data of this type, on foundry dust, is shown in Figures 17, 18 and 19. In Figures 17 and 18, the water flow to the gun was held constant, but the time of grinding was varied in order to change the dust particle spectrum.

In Figure 18, the emphasis was on the 0.5 to 4 micron respiratory range, while in Figure 19 the dust was ground still further to build up the one micron fraction. In both cases, the charged fog was very effective in controlling the dust. This is especially evident in Figure 19 at the one micron level. These results might have been anticipated from Figure 9 where it was shown that the one micron sized foundry dust had a negative charge. We would expect this dust to interact quite strongly with oppositely charged fog. Figures 17, 18 and 19 indicate that this interaction did, in fact, occur.

Other studies of this type were done with silica sand and silica flour to determine if similar results could be obtained. The data is shown in Figures 20 and 21. It seems quite clear that the charged fog system is effective in reducing these particulates.

Further data on magnesium oxide dust is shown in Figure 22*. Here the interest was in the rate of reduction of dust density after fogging began and for this reason data was taken as a function of time. It is apparent that there was a substantial reduction after 0.5 minutes, when charged fog was used. In contrast, we note that the effect of uncharged fog was only really apparent after some two minutes. This difference is a measure of the effect of charging as a mechanism for improving the contact between dust and water fog.

Other data showing the effect of charged fog on silicon carbide dust and nickel mine precipitator dust are shown in Figures 23 and 24. Data on bauxite ore, calcium oxide, dolomite, cement clinker, iron oxide, sulfur and Pb_3O_4 are shown in Figures 25, 26, 27 and 28. Here again charged fog was effective in suppressing all of these dusts, provided that the proper polarity was used. Similar results were obtained with rock salt, the fumes from burning Carbamite (an ammonium nitrate compound used for underground blasting), a silicate ore sample provided by a local mine, and a mixture of lead oxides from a battery production facility, Figures 29, 30, 31 and 32.

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*Some of this data was obtained with a GCA Corporation RD-101 Dust Monitor. This unit makes use of a beta ray absorption system and in some cases, where there was significant absorption of fog by the dust, it appeared that the dust plus uncharged fog density was higher than the initial dust density itself. The data was corrected for this water absorption, as shown in the figures, by subtracting a percentage from each vertical bar. This value was obtained by taking the difference between the no-fog and the uncharged fog data, dividing by the height of the uncharged fog bar and multiplying the other data bars by this value.

In all of the above cases there was a significant difference between the effects of positive versus negatively charged water fog. This would be expected from the earlier discussion of dust charging. However, we have noted some cases in which the charge of the fog does not have a significant effect on the suppression of respirable dust. Typical examples are shown in Figures 32 and 33 for an industrial red lead and trona dust $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$ from a commercial mine. We suspect that these samples contain materials that charge both positively and negatively (a mixture of red lead and sulfur would display this characteristic). Little coagulation occurs when the materials are very dry, if charged fog is used one of the components is wetted and agglomeration of both species occurs. This is speculation at present and the phenomena will be the subject of further investigation.

C. Effects of Reduced Water Flow and Chemical Additives

Another aspect of the study was aimed at evaluating the effects of reduced water flow on dust control. Typical results are shown in Figure 32, where we have plotted the percent reduction of respirable foundry dust with uncharged (30 ml/min) and with charged water at flow rates of 30, 16 and 3.2 ml per minute. The largest reduction was observed with charged fog at 30 ml/min, but the significant reduction was observed even at 3.2 ml/min. This suggests that only a limited amount of fog will be required for effective dust control. A calculation of the effect of these fog levels on the humidity, in a typical foundry, is given at the end of the paper.

There have been suggestions that various dust control chemicals, detergents, etc., be added to the water in order to improve the dust control system or make the agglomerates more stable. We have resisted this idea on the basis that no dust control chemicals have FDA approval for human exposure. Anyone working in the area where the charged fog was used could certainly be exposed to the vapors and the effects of dust control chemicals have simply not been evaluated in this mode. We have done studies with various mixtures of glycerine (glycerol) and water in cases where the fogging technique might be used at low temperatures. (Subfreezing temperatures are frequently encountered in the iron mines of Minnesota and Ontario.) Glycerine has FDA approval for oral, dermal and rectal application and a 50/50 mixture with water has a freezing point of -23 C.

Typical glycerine/water data with iron mine crusher dust is shown in Figure 35. Here the dust was run first with (+) and (-) charged water and then the experiment was repeated with a 50/50 glycerine water mixture. In both cases the (+) charged fog was most effective with a slight bias in favor of the pure water rather than the water glycerine mixture though the difference was not very significant.

We suggest that mixtures of glycerine and water can be used for dust suppression and may be especially valuable under freezing conditions or when there is a tendency for the dust to redisperse. In the case of certain lead dusts, the glycerine seems to hold the agglomerate together even in weak 10/90 glycerine/water solutions.

D. Studies of Coal Particulates and Coal Tar Volatiles

The increased burning of coal raises the hazard of greater public exposure to fly ash, coal particulates and the volatiles generated when coal is heated. An investigation of the effect of charged fog on these pollutants involved first the grinding of coal*, in a nitrogen atmosphere to preclude explosions, to obtain a fine powder. This powder was blown into the dust tunnel with nitrogen (in place of air) and fogged. Typical results are shown in Figure 36. As usual the respirable material was found to be negative and was effectively suppressed by positively charged fog.

To investigate coal tar volatiles, a metal pipe some 100 mm in diameter was cut off and sealed with screw caps to form a closed tube some 300 mm long. The tube was filled with coarsely ground coal*, provided with a 10 mm tube to permit vapors to escape and heated to 700 C in a small oven. The vapors were blown into an outside dust tunnel and exposed to charged fog. Two experiments were done. One was to observe volatile particulates that were usually collected on filters. The other experiment was aimed at observing benzene solubles. The data on volatile particulates is shown in Figure 37. The (+) charged fog was most effective in reducing this pollutant.

Measurement of these benzene soluble vapors involved drawing the fumes through a bubbler containing a benzene solution for absorption; the benzene was then analysed by a gas chromatograph (GC). A typical

*Pittsburg Seam #8 Coking Coal (Ohio)

test involved first making a GC run with benzene alone, then a run was made with benzene after absorption of coal tar volatiles, and a last run was made with benzene and coal tar volatiles where the volatiles were fogged, with (+) fog, before reaching the benzene absorbent.

Typical results are shown in Figure 38. In the presence of charged fog there was a marked reduction in pickup of benzene solubles by the bubbler suggesting that this material had been induced to agglomerate and fallout in the tunnel before reaching the collecting device. We suggest that there may well be applications for charged fog in the control of coal dust and coal tar volatiles.

Experiments with SO_2 and Fly Ash Plus SO_2. Sulfur dioxide is found as a purely gaseous pollutant in certain copper smelting operations but in most cases is associated with substantial quantities of dust or particulate matter. This is especially the case in coal fired power plants where control of fine (one micrometer) fly ash and SO_2 is difficult with conventional precipitators, wet scrubbers and bag houses.

Our first studies, of SO_2 alone, were designed to observe the interaction, if any, between charged fog and SO_2. There had been some indication that SO_2 aerosols were negatively charged and to investigate this, SO_2 was provided from burning sulfur or commercial tank, and exposed to charged water fog. Typical results, at room temperature, are shown in Figure 39. Experimental data obtained in the heated test rig of Figure 40 produced the data shown in Figure 41. There seems to be no question that (+) charged fog is effective in reducing the level of

SO_2 even at 381 C. We suggest that the fog combines with the SO_2 to form large drops of H_2SO_4 whose vapor pressure is low enough to preclude evaporation even at the test temperatures.

The experiments with fly ash began with "pure" fly ash (without added SO_2). Typical results are shown in Figure 42. The (-) charged fog seemed to be most effective in this case, but this result may be limited to the particular fly ash involved or to the fact that the test was run at ambient temperature. After consultation with the power company involved, the study was repeated with the fly ash at 200 C. Once again charged fog was effective in suppressing the dust (typical results are shown in Figure 43), but several experiments indicated that now the (+) charged fog was most effective. We have no explanation for this at the moment. The question of charging as a function of external parameters, i.e., heating, is under investigation at the moment.

At this point, we began experiments with mixtures of SO_2 and fly ash. There have been many reports (Reference 11, pages 105-189) of improvements in collection and adhension characteristics of fly ash in the presence of SO_2 or NH_3. In fact, most commercial fly ash additives contain one or both of these chemicals. It is worth noting that the exact mode in which these chemicals serve to improve collection is by no means clear and one objective of our experiment was to clarify the SO_2 fly ash interaction.

The first studies involved grinding the fly ash in the arrastra mill and blowing it into the dust tunnel while at the same time adding a measured flow of SO_2. The sulfur dioxide studies were hampered by a

a lack of detection apparatus but the experiment served to define possible applications of the charged fog technique. Typical results at ambient temperature are shown in Figure 44. The addition of SO_2 raised the measured dust level appreciably. We associate this with absorption of SO_2 onto the dust thereby raising the weight of the particles. With (+) charged fog there was a significant reduction in the dust level. If SO_2 was not present the dust reduction was even greater suggesting that in the presence of SO_2 some of the injected fog is taken up by the gas and therefore unavailable to the dust. In an industrial situation this could be remedied by simply increasing the quantity of charged fog.

For the next experiment we were able to make some numerical determinations of SO_2 level, by a wet chemical technique, and typical results for dust and SO_2 are shown in Figure 45. Here the initial dust density is shown with an added SO_2 content equivalent to 13.2 mg/m^3. After fogging the dust level fell to the lower curve and the SO_2 level fell below the sensitivity of our instrument 0.26 mg/m^3.

The next set of studies made use of the experimental system shown in Figure 40. Here the interest was to determine the effects, if any, of the high temperature on the reaction. Typical results are shown in Figure 46. There was a significant reduction in dust density and a moderate reduction in the SO_2 level. The limited effect of the fog on the SO_2 may be due to the use of a different and much more acid fly ash, from a local mine. This ash may have captured a majority of the fog so rapidly that little was left to absorb SO_2. These effects will be investigated in more detail as the program developes.

These SO_2/fly ash investigations are obviously in the very beginning stages, equipment is still being ordered and set up. Nevertheless, there is every indication that when a mixture of SO_2 and fly ash is exposed to charged fog the fog divides between the SO_2 and the fly ash. Fog absorbed by the fly ash is tightly held and induces dust agglomeration; the fog that interacts with the SO_2 forms dilute sulfuric acid that is absorbed by the dust particles to produce a highly adhesive agglomerate. Two photographs are shown in Figure 47; the upper shows the agglomerate formed with SO_2 plus fly ash, the lower shows the effect of adding charged fog. Not only are the agglomerates somewhat larger but there are whiskers which we suspect are sulfur since they could not be imaged in the scanning electron microscope.

These absorption and agglomeration effects suggest that it might be possible to remove both pollutants (SO_2 and fly ash) at the same time by spraying with charged fog. The resultant agglomerates are large (typically thirty micromenters) and ideally suited to collection by precipitators or wet scrubbers. This combination of effects could significantly improve the control systems installed on a wide variety of power plants and smelters.

E. Control of Dust From Hand Grinders, Chippers and Sanders

These tools are a source of dust and since they are often used in confined areas, where hoods would interfere with the work, they are a potential factor in workman injury. Some companies have marketed collectors and vacuum manifolds to go on the grinder but in general

these units have not been popular because they change the balance of the tool and interfere with the workman's view.

We have developed* a system for adding small quantities of water fog to the contact area between the tool and the work. This effectively reduces the respirable dust level while at the same time acting as a cooling agent. Typical results with a grinder and chipper are shown in Figures 48 and 49. In each case there was a significant reduction in dust level and operator comments indicated that grinding seemed more efficient. The water dispensing and controlling system did not interfere with the operation of the tool.

Arrangements are being made with a manufacturer of hand tools to bring this device into the commercial market. Further development of systems to reduce dust during wire brushing, swing grinding and electric arc washing are under way.

III. Industrial Testing

The laboratory work, while encouraging, was not a guarantee that the system would operate in the more rigorous environment of the industrial plant. For this reason, a test program was organized at several locations in southern Arizona and at a number of other industries in various parts of the United States and Canada. For some tests the University participated directly in the setup and operation of the experiment. In other cases the fog guns were simply loaned or rented to the

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*This device is the subject of a patent disclosure to the Ransburg Corporation of Indianapolis, Indiana.

organization for try out. This proved to be a problem in some situations where corporate personnel were not familiar with dust sampling procedures or how to set up for a test of this kind. As a result there were some inconclusive tests and in a few cases negative results were obtained. This problem is being slowly solved as test equipment is refined and more time is available for assisting the corporation during the test.

Some of the results obtained by the author, or by industrial personnel, under controlled conditions, are discussed below. At the present time tests are under way at some fifty industrial locations.

A. Cement Plant "A"

A sample was taken from the belt conveyor in the quarry surge building. The dust was tested in the system, shown in Figure 2 and the results are shown in Figure 13. It is clear that this dust was primarily negative in sign, and positively charged fog should be used. The in-plant fog tests made use of two modified Ransburg REA guns, mounted as shown in Figures 50 and 51. The curtains shown in Figure 51 were used to prevent dust from blowing in or out of the test area. In the case of Figure 50, we were interested in the dust suppression right at the hoppers. In Figure 51, the reduction in dust in the working area was of importance. The results are shown in Figures 52 and 53. In both cases, there was significant reduction in the dust level.

B. Copper Company "A"

Dust samples were taken from a concentrate conveyor in the smelter and tested in the dust tunnel of Figure 2. The charge vs. size

data was shown in Figure 12. It is clear that the smaller respirable material is positive in sign, indicating that negatively charged fog should be used.

The experimental set up for this test made use of one Ransburg REA gun, as shown in Figure 54. There was some difficulty with high ambient winds blowing the dust and fog about, but it was possible to take data by sampling with a GCA RD-101 beta ray adsorption system. The results are shown in Figure 55.

In another test, at the same company, the fog gun was set up at a conveyor drop box as shown in Figure 56. Some eleven samples were taken without fog and seven samples with (+) charged fog. The average reduction in dust level was some 65.4%. This was felt to be satisfactory in view of the many other dust sources in the area and the high winds that happened to be blowing that day.

C. Steel Casting Company "A"

The test area for this study was a standard railroad boxcar used for shipping silica sand. Under normal conditions, the dust level during unloading was quite high. The control system involved four RAnsburg REA guns fastened to the inside roof of the boxcar as shown in Figure 57. The dust levels during unloading were monitored by MSA Gravimetric Dust Samplers for a two hour working period. The total dust level and the fraction of free silica were measured with and without charged fog. The results are shown in Figure 58. It is apparent that both the total dust concentration and the respirable silica level were significantly reduced.

It is interesting to note that the free silica was reduced by a factor of $\frac{1.09}{0.19} = 57.4$, suggesting that the positively charged fog was most effective on the negatively charged (Figure 15) silica dust. This very significant effect is a measure of the effectiveness of the charged fog technique. Further experiments in this facility are planned.

D. Steel Company "B"

One of the more troublesome operations in this facility was the bag splitting room where operators were exposed to high levels of respirable dust. This area was set up with two fog guns blowing into the splitting hood. Samples were taken at two fixed points in the hood area and a third sampler was attached to the workman and operated by a battery driven pump.

Typical results are shown in Figure 59. There was a significant dust reduction at the fixed locations but the greatest improvement was measured by the sampler on the workman. This was most encouraging and further studies in this faciltiy are under way.

IV. Humidity Increase Due to Fogging

This is of some importance in areas where the addition of water vapor might damage delicate equipment or interfere with industrial operations. To evaluate this effect, we consider a fog gun air flow of some 100 SCFH ($2.8 m^3$/Hr) and a water flow of some A ml/min or $2.21 \cdot 10^{-3}$ A lb/min (1.003 g/min).

This air flow will mix with ambient air after it leaves the gun. In an open-shop situation, where the supply of ambient air is essentially unlimited, the mixture ratio will be about 100 giving an effective air flow of some 10^4 SCFH 283 m^3/Hr toward the target. If this "factory air" is 80°F (26.7 C) at 50% RH, its initial moisture content will be 0.011 lb H_2O per lb air (0.011 g H_2O/g air).

The density of air at the above conditions is some 0.079 lb/SCF (0.00128 g/m^3). This flow represents some 13.2 lb/min (6000 g/min) of air with an initial water vapor content of 0.145 lb H_2O (65.83 g H_2O).

In the flow of water to the fog gun is some 30 ml/min (a rather large value), the total water added per minute will be some 0.064 lb H_2O (29.1 g H_2O). If we add this to the initial water vapor level of 0.145 lb (65.83 g H_2O) the total is 0.209 lb H_2O (94.9 g H_2O) or 0.0159 lb H_2O/lb air (0.0159 g H_2O/g air). The new RH (assuming constant temperature conditions) is some 70%, insufficient to damage industrial appartus.

If the water flow is reduced to some 5 ml/min (0.011 lb/min), the fogging technique is still quite effective (Figure 34). Under these conditions, the RH rises from an initial 50% RH to some 67% RH (assuming constant temperature).

This calculation has been done for open shop conditions. In ducts or tunnels where the flow of ambient air is limited, higher relative humidity values will be generated. If this is a problem, it should be possible to further reduce the water flow, provided that better atomization of the water can be achieved. The number of drops obtained from a given volume of water varies as the third power of the radius, i.e., $V = \frac{4}{3}\pi R^3$.

The limiting charge per drop varies as the square of the radius $NE \simeq AR^2$ (where A is a constant). Reducing R by a factor of 10 increases the number of drops by a factor of 1000. The allowable charge per drop decreases by a factor 100, permitting an approximate gain in effectiveness of a factor of 10. Conversely, the quantity of water might be reduced by a factor of 10 without loss of efficiency.

In the case cited above reduction of water flow from 5 ml to 0.5 ml per minute reduces the rise in relative humidity from some 17% RH to less than 1% RH.

22

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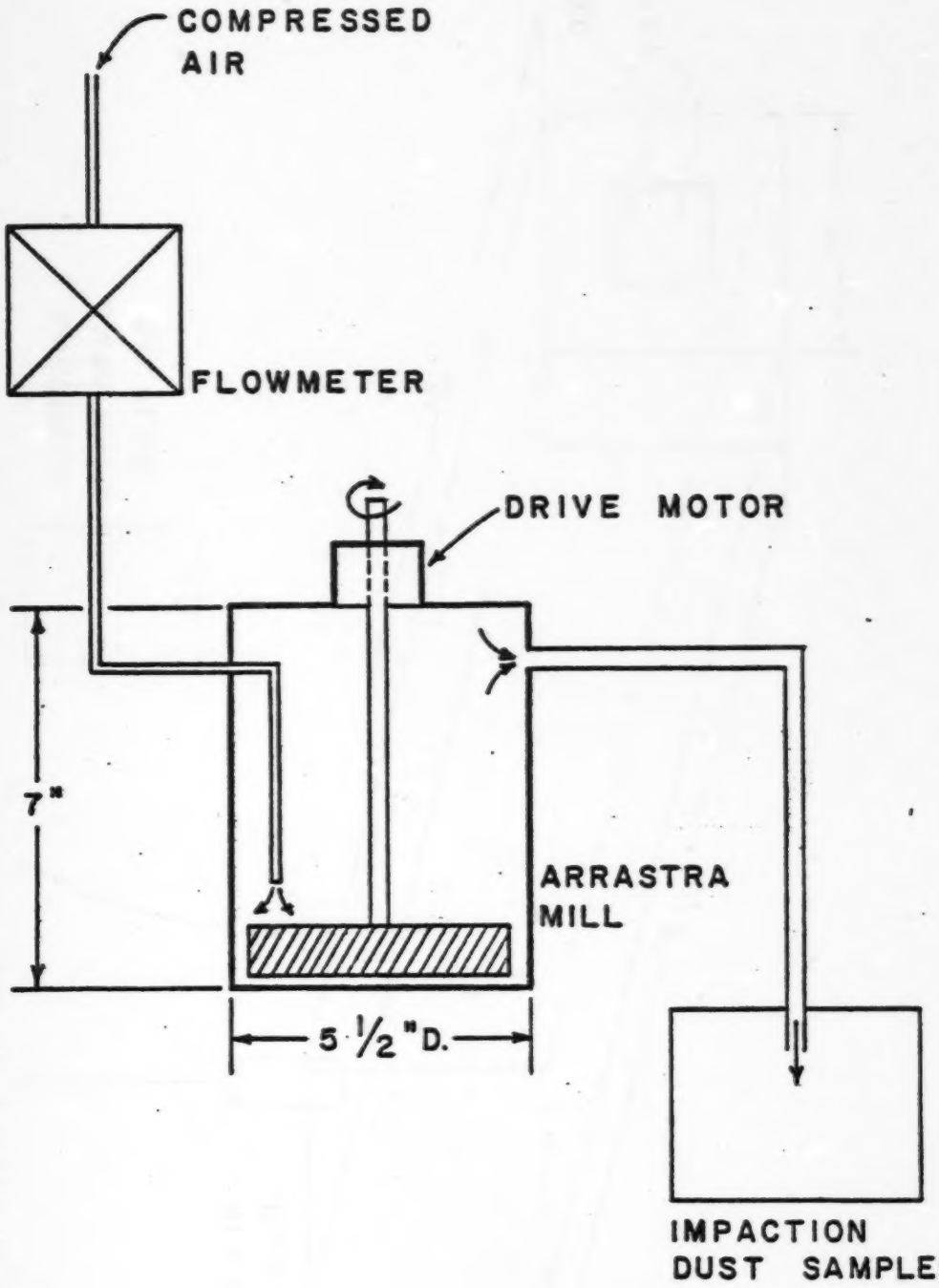
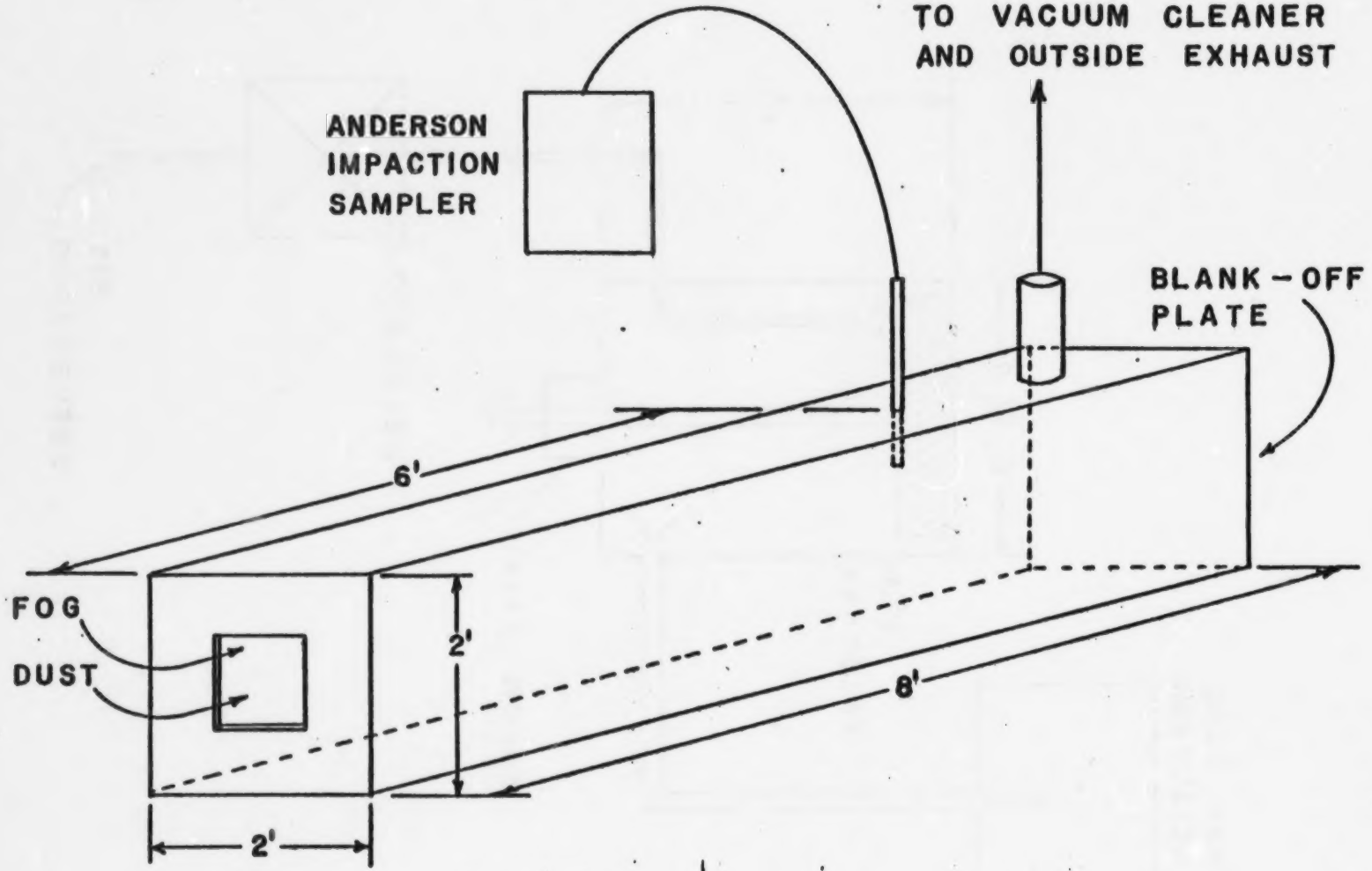
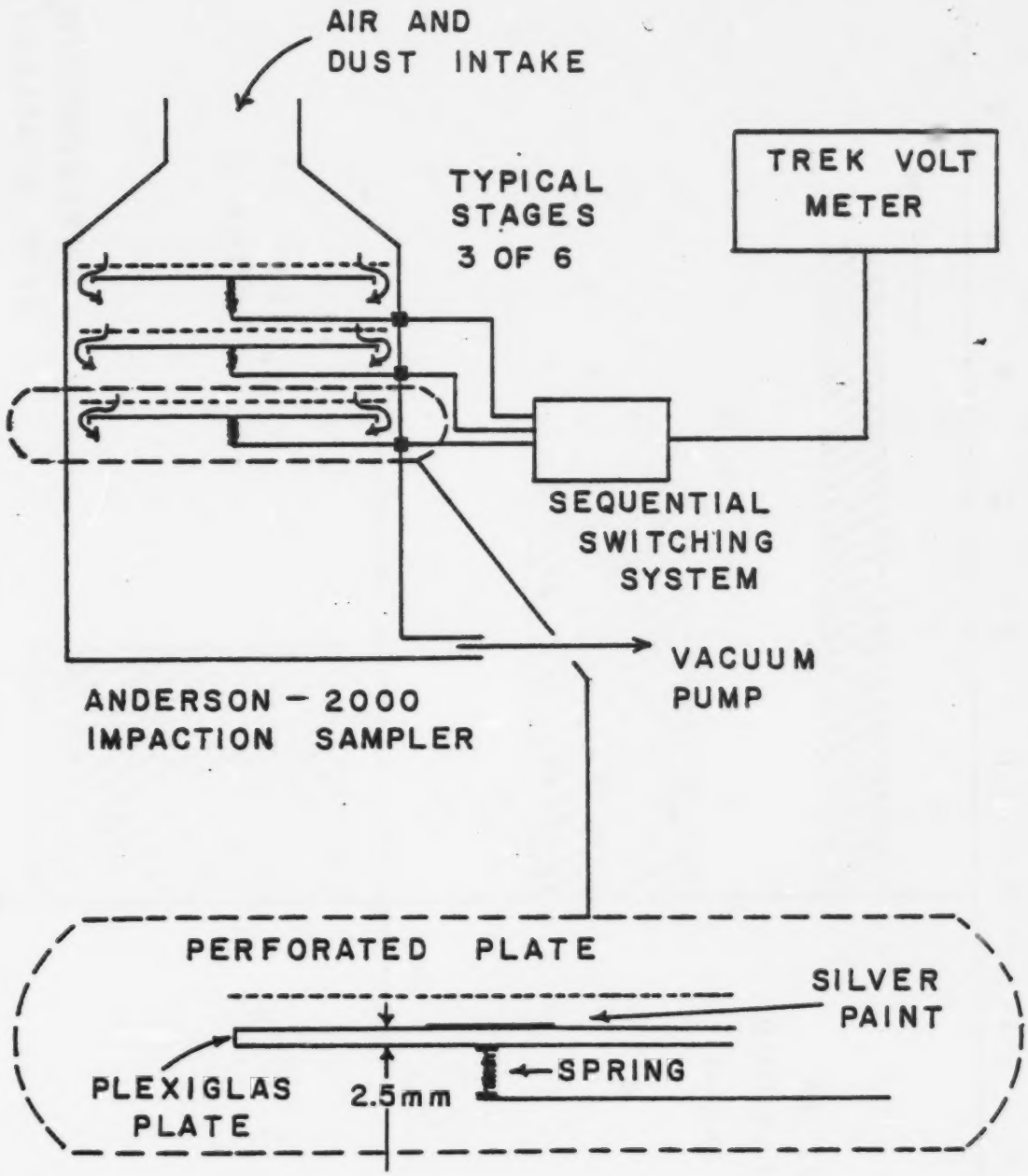
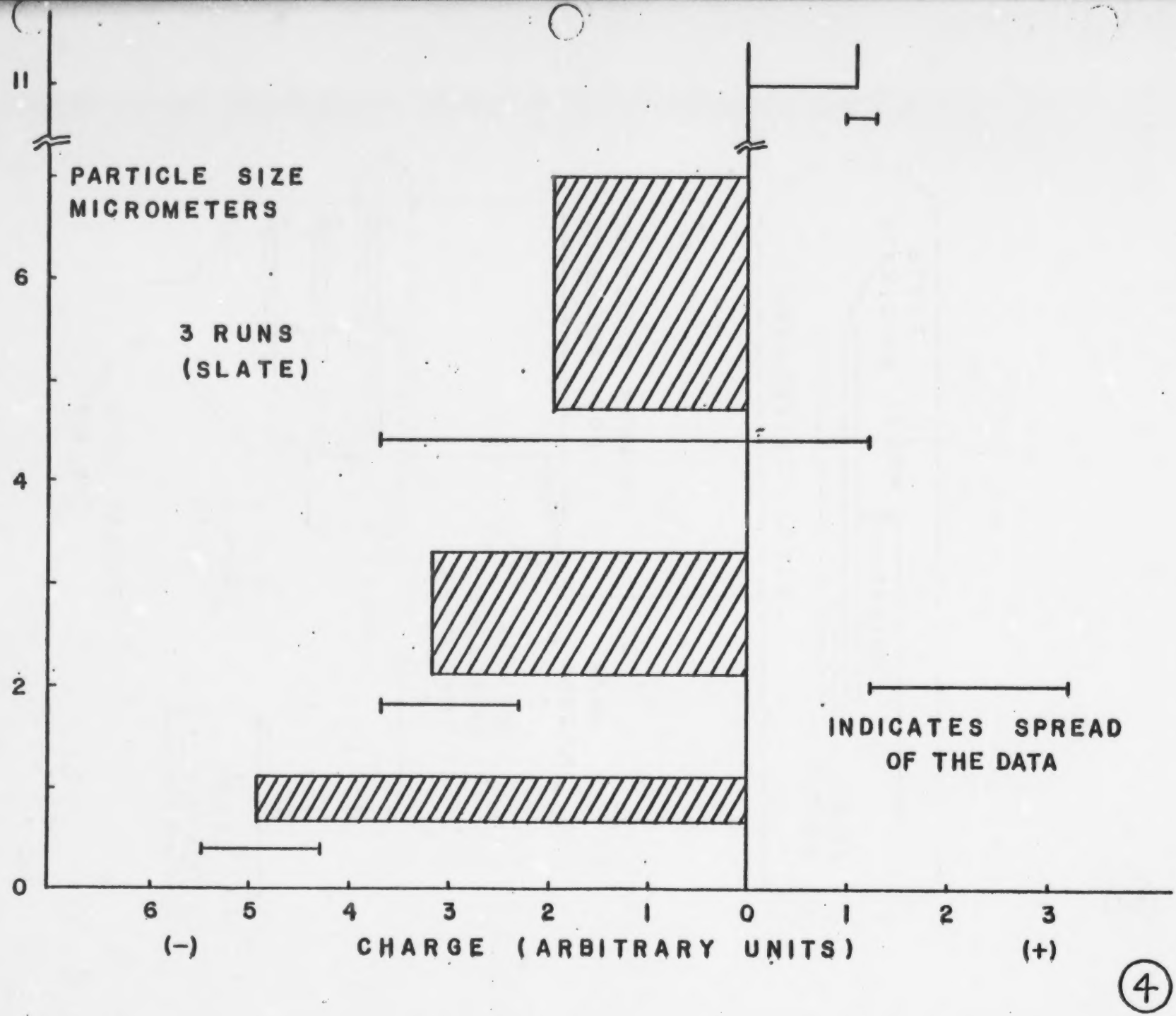


DUST GENERATOR AND SAMPLING SYSTEM (1)

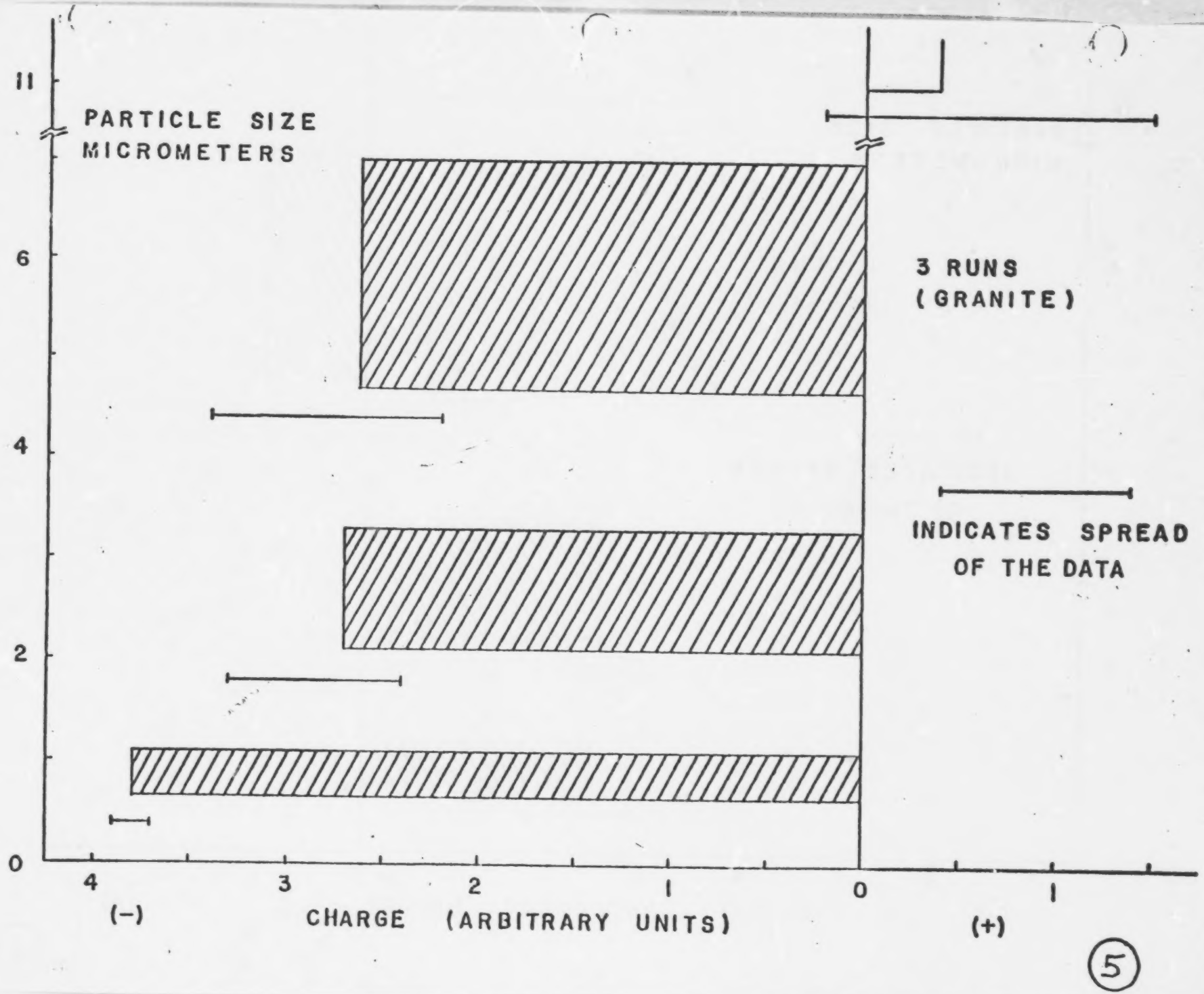


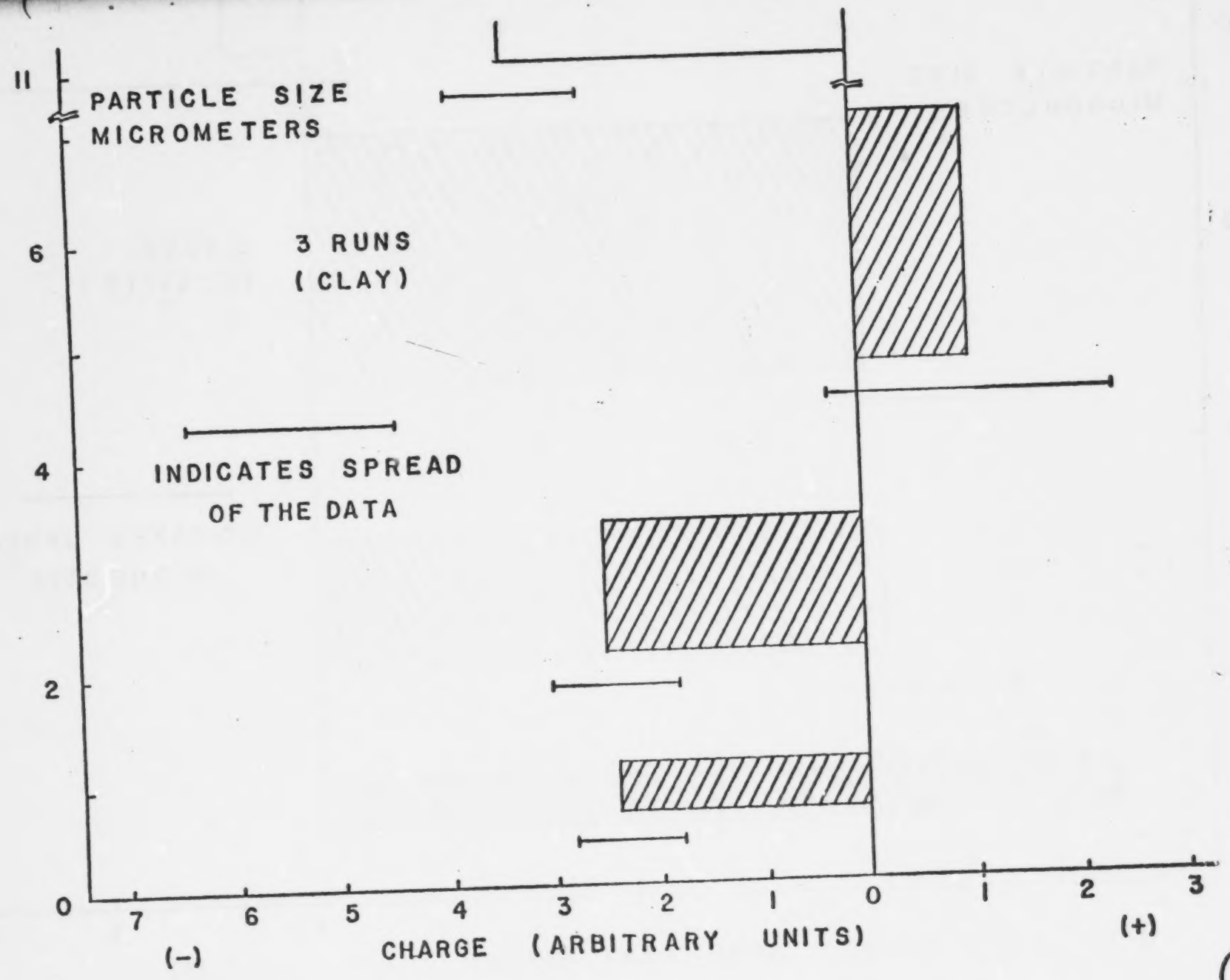
EXPERIMENTAL DUST TUNNEL


AIR AND
DUST INTAKE
TYPICAL
STAGES
3 OF 6
TREK VOLT
METER
SEQUENTIAL
SWITCHING
SYSTEM
VACUUM
PUMP
ANDERSON – 2000
IMPACTION SAMPLER
PERFORATED PLATE
SILVER
PAINT
SPRING
PLEXIGLAS
PLATE
2.5mm

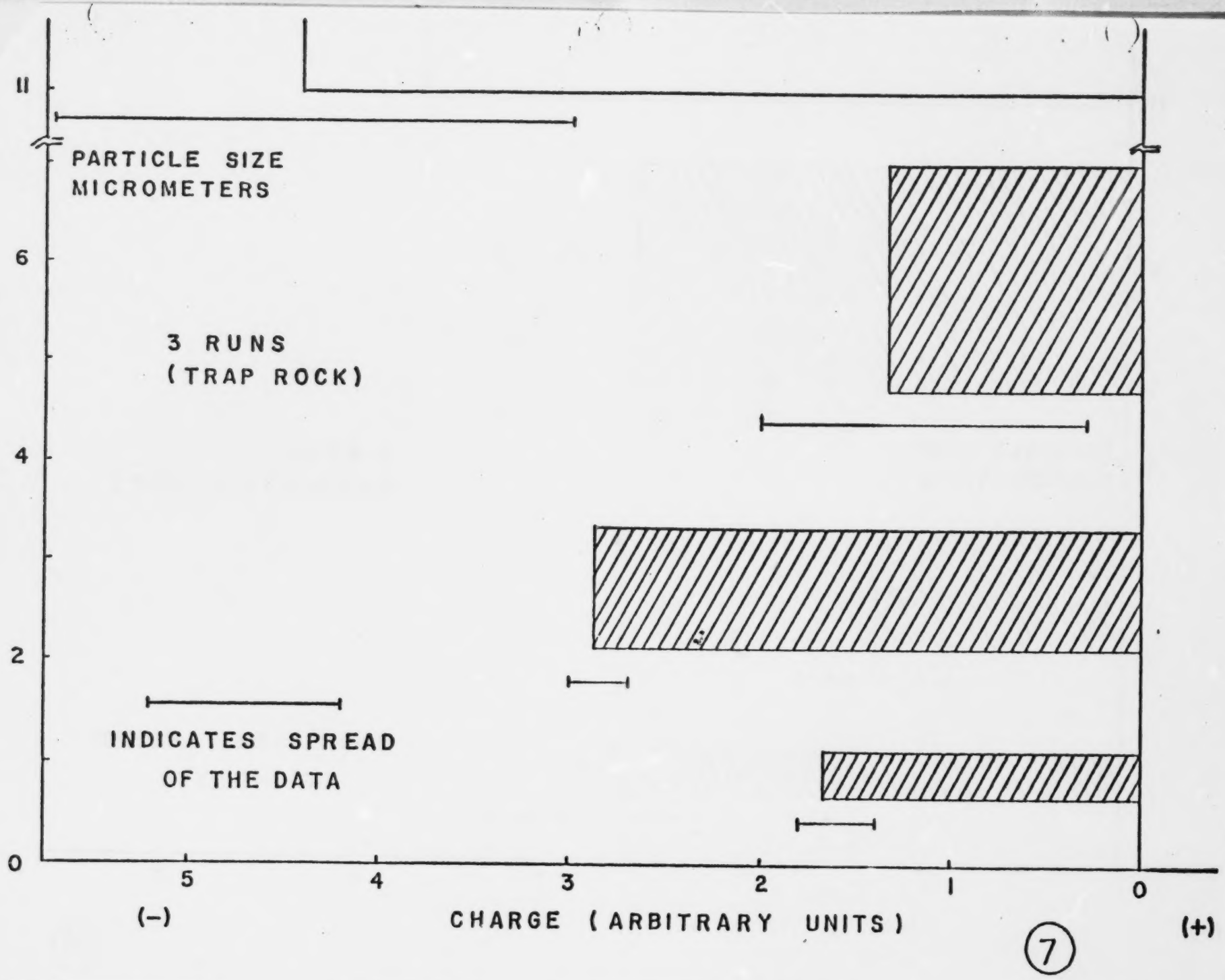

11
6
4
2
0
PARTICLE SIZE
MICROMETERS
3 RUNS
(SLATE)
INDICATES SPREAD
OF THE DATA
6
5
4
3
2
1
0
1
2
3
(-)
CHARGE (ARBITRARY UNITS)
(+)

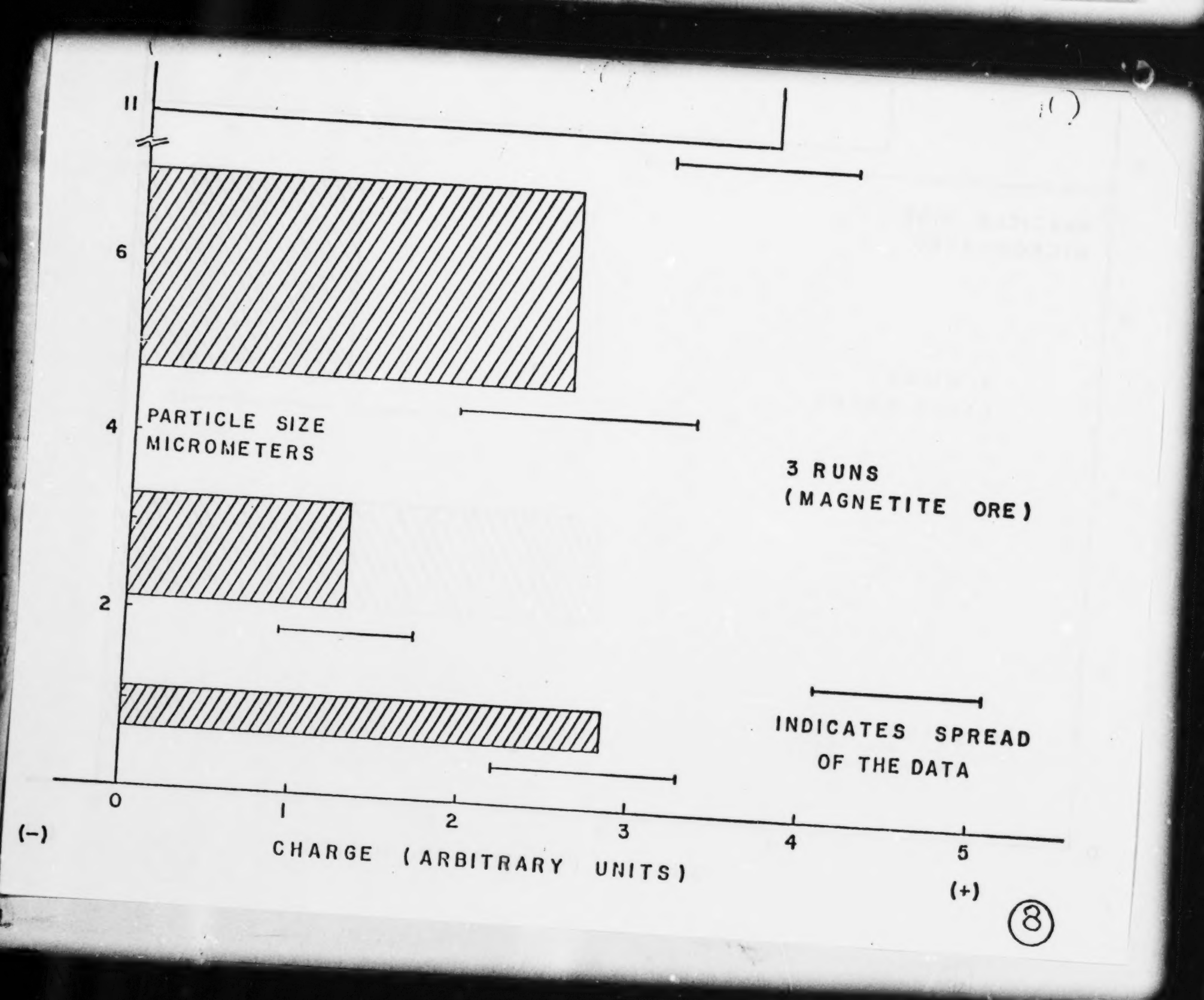
(4)


11
PARTICLE SIZE
MICROMETERS
6
4
2
0
3 RUNS
(GRANITE)
INDICATES SPREAD
OF THE DATA
4
3
2
1
0
1
(-)
CHARGE (ARBITRARY UNITS)
(+)


PARTICLE SIZE
MICROMETERS
11
6
4
2
0
3 RUNS
(CLAY)
INDICATES SPREAD
OF THE DATA
7
6
5
4
3
2
1
0
1
2
3
(-)
CHARGE (ARBITRARY UNITS)
(+)

6


11
PARTICLE SIZE
MICROMETERS
6
3 RUNS
(TRAP ROCK)
4
2
INDICATES SPREAD
OF THE DATA
0
5
4
3
2
1
0
(-)
CHARGE (ARBITRARY UNITS)
(+)


11
6
4
2
PARTICLE SIZE
MICROMETERS
3 RUNS
(MAGNETITE ORE)
INDICATES SPREAD
OF THE DATA
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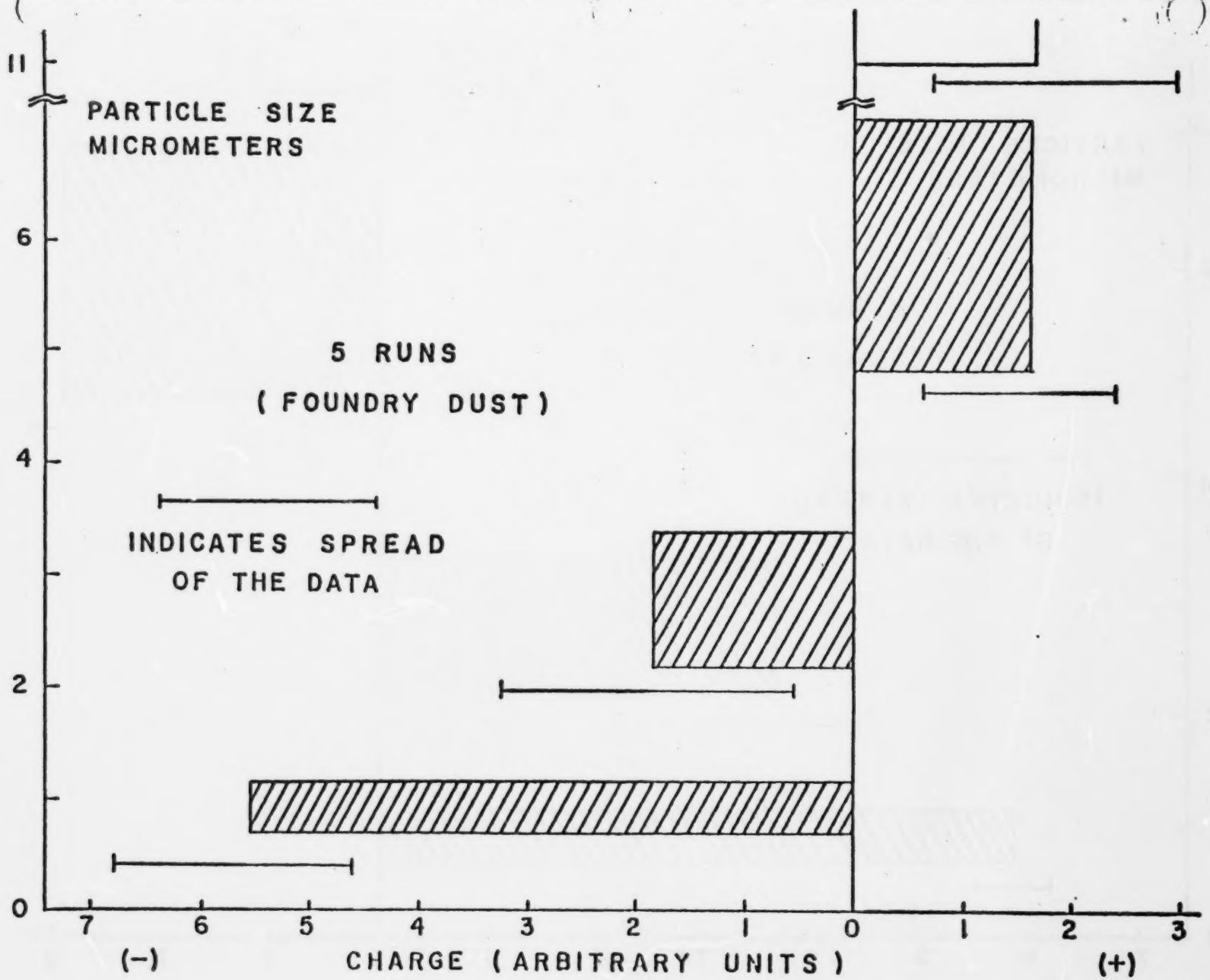
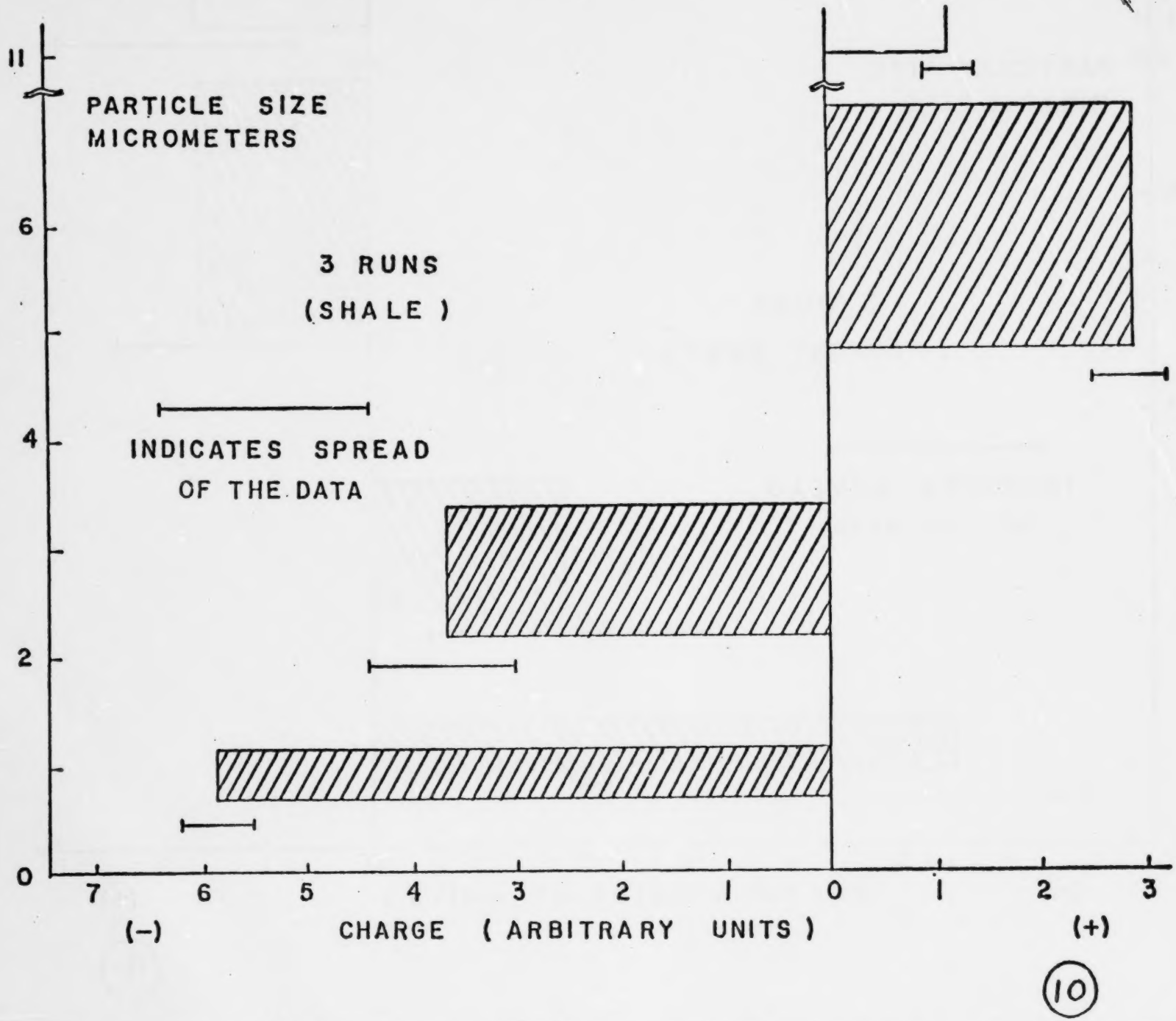
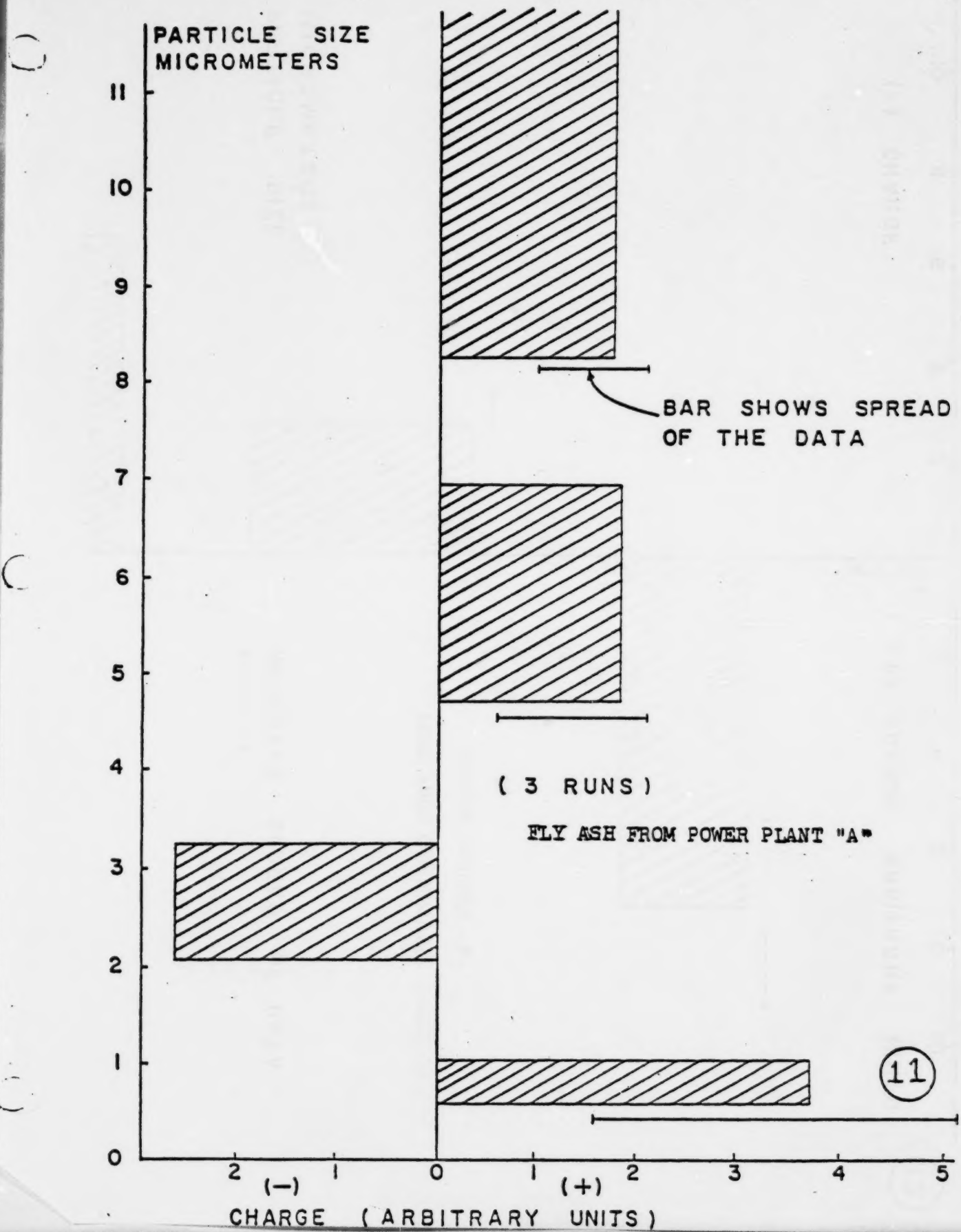
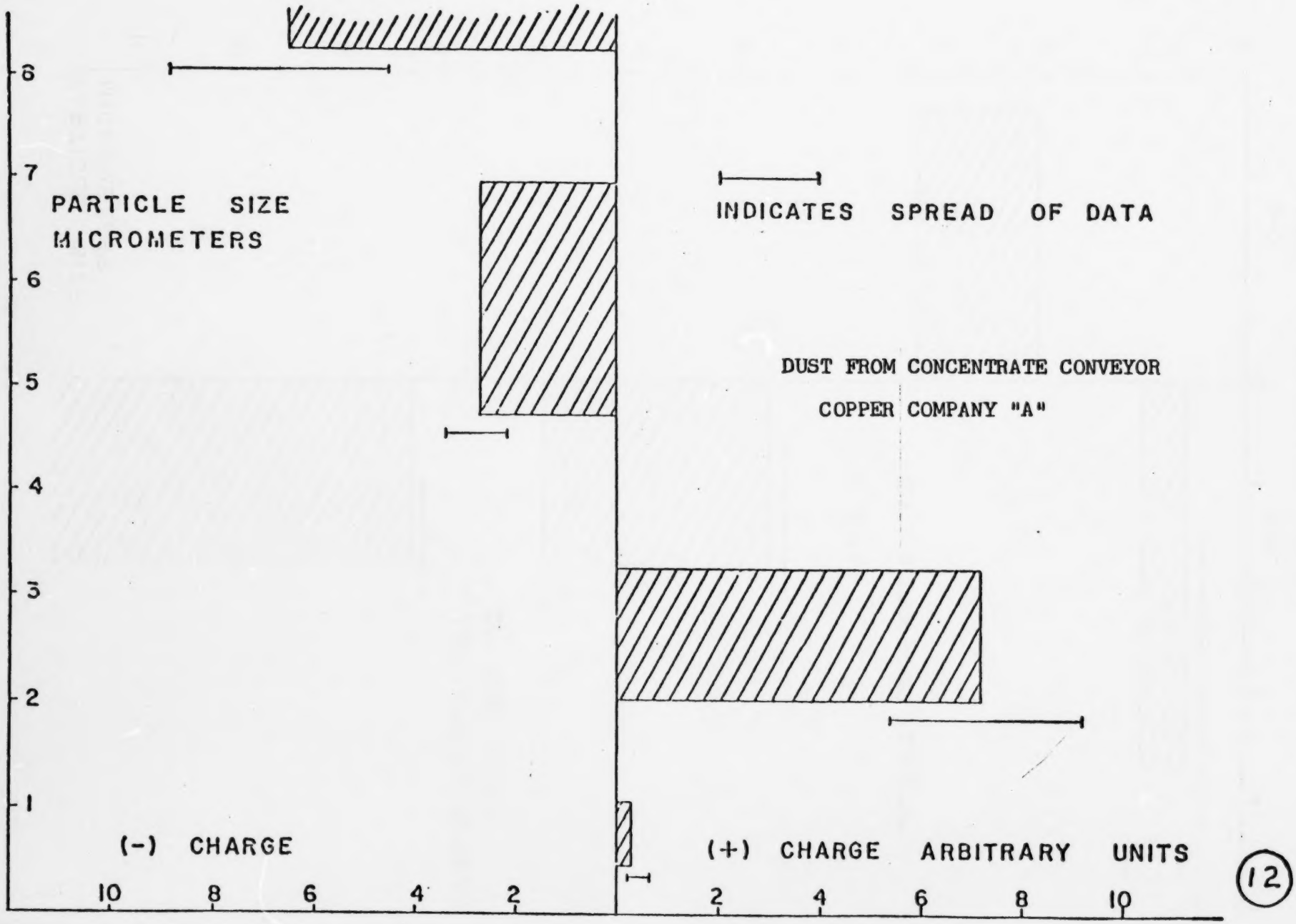
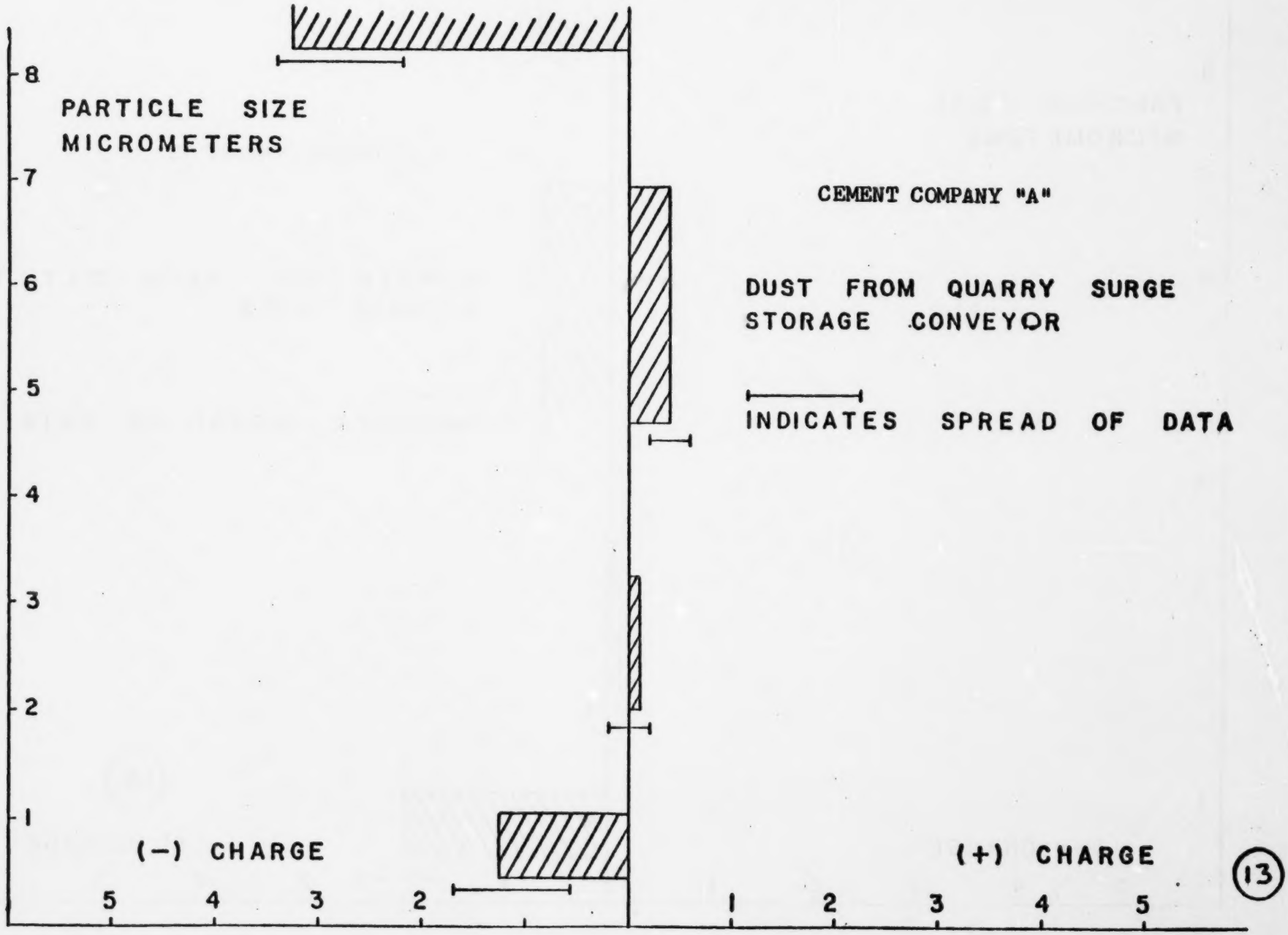
1
2
3
4
5
(-)
(+)
CHARGE (ARBITRARY UNITS)

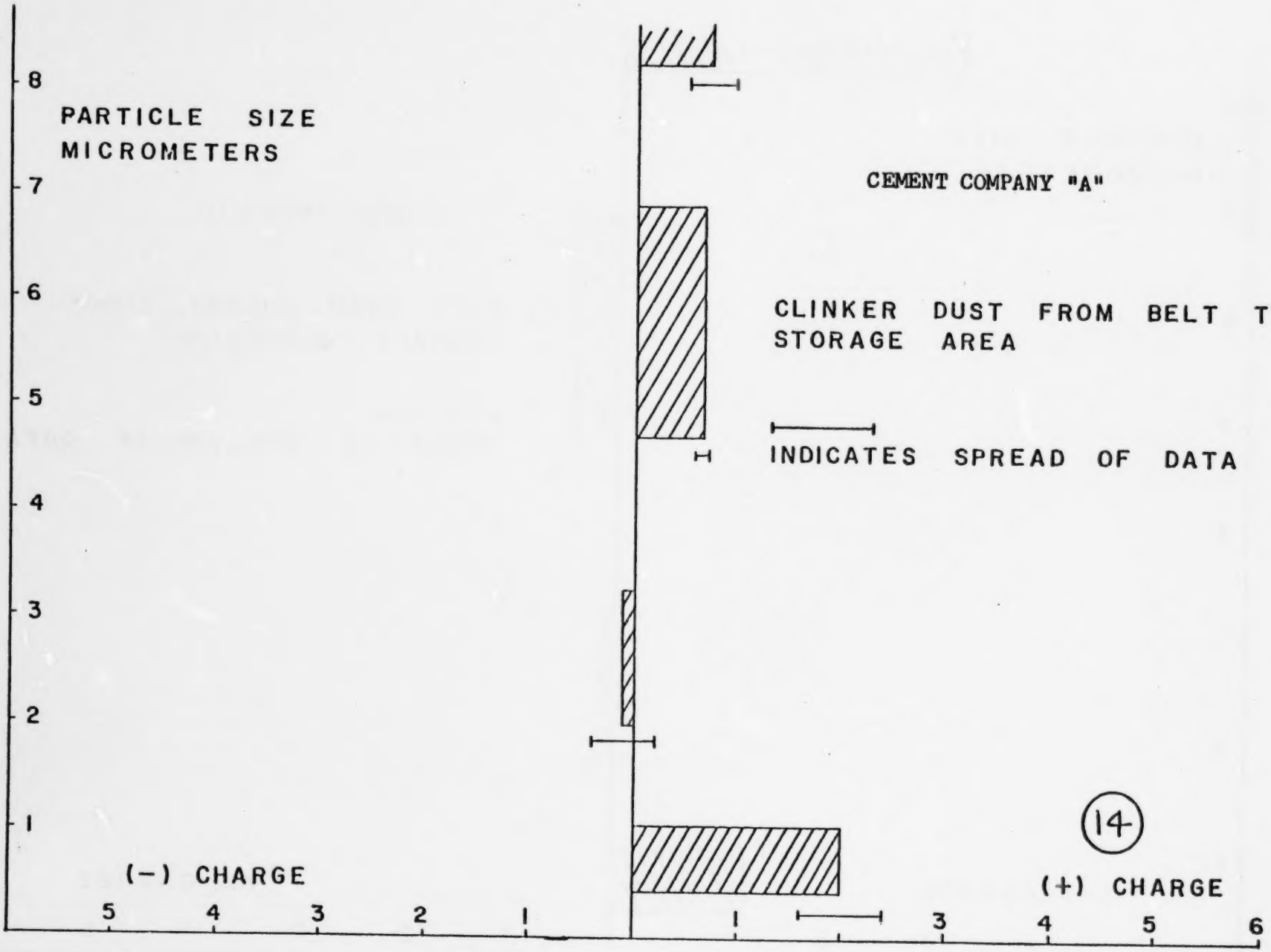

11
PARTICLE SIZE
MICROMETERS
6
5 RUNS
(FOUNDRY DUST)
4
INDICATES SPREAD
OF THE DATA
2
0
7
6
5
4
3
2
1
0
1
2
3
(-)
CHARGE (ARBITRARY UNITS)
(+)

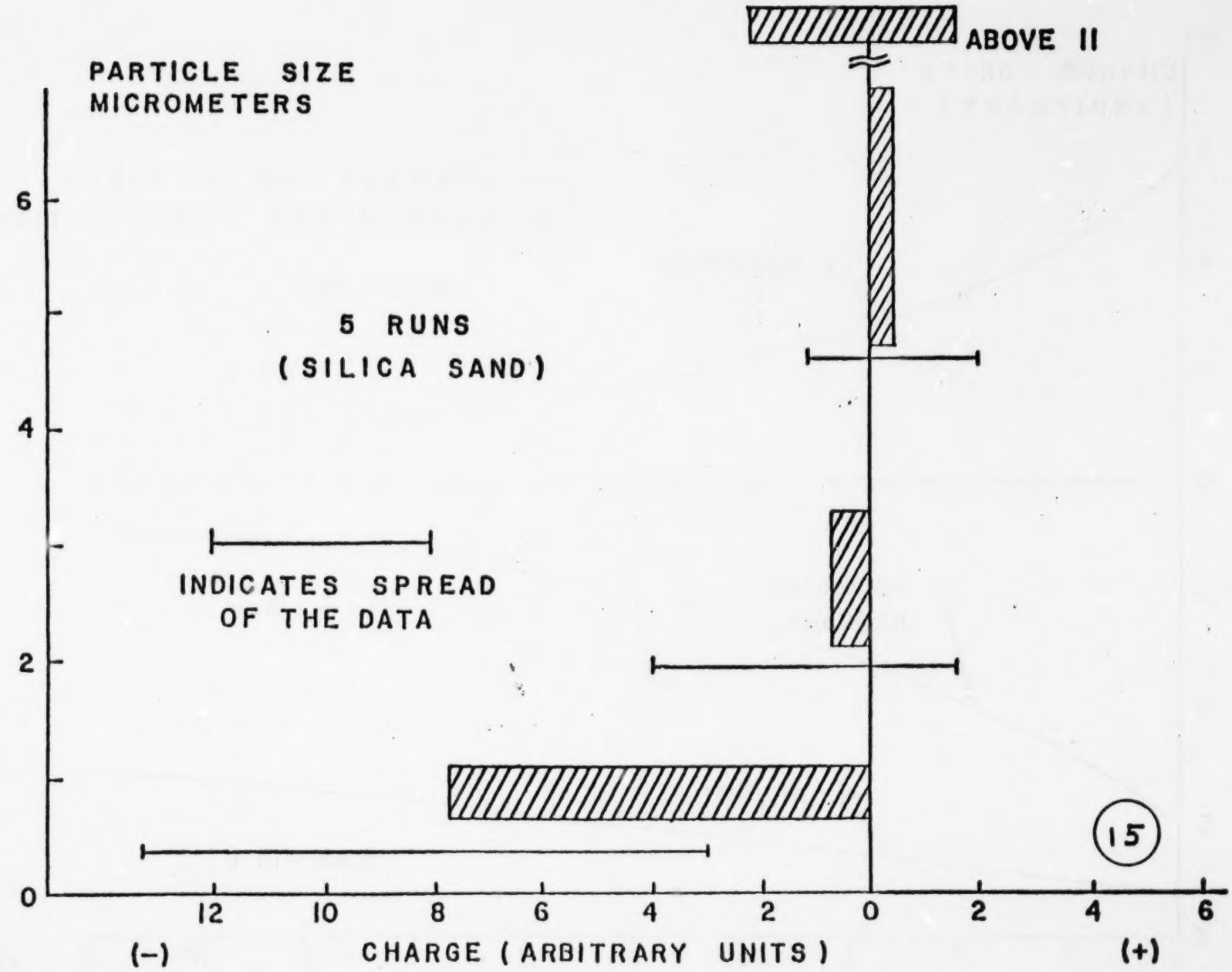

11
6
4
2
0
PARTICLE SIZE
MICROMETERS
3 RUNS
(SHALE)
INDICATES SPREAD
OF THE DATA
7
6
5
4
3
2
1
0
1
2
3
(-)
CHARGE (ARBITRARY UNITS)
(+)

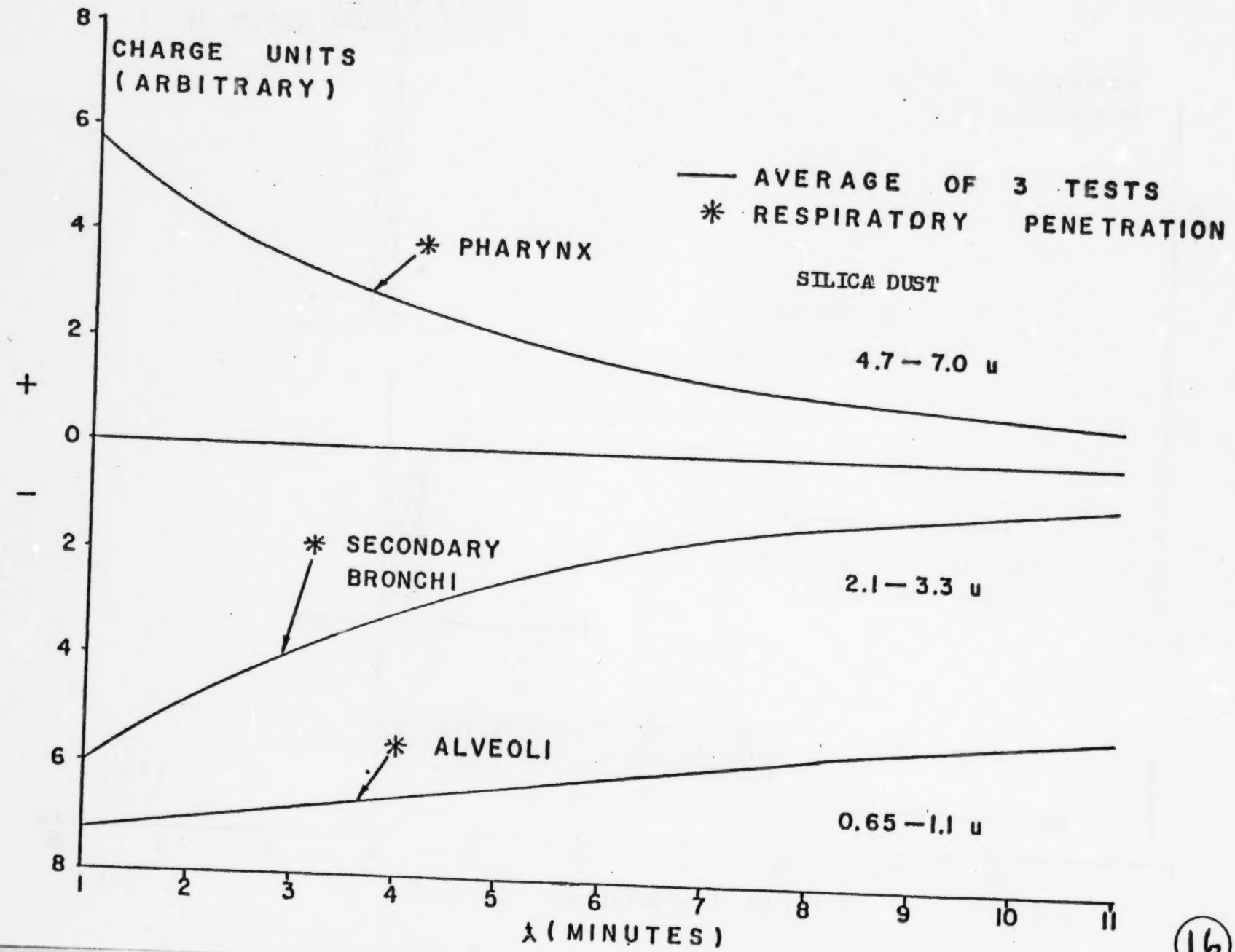

PARTICLE SIZE
MICROMETERS
11
10
9
8
7
6
5
4
3
2
1
0
BAR SHOWS SPREAD
OF THE DATA
(3 RUNS)
FLY ASH FROM POWER PLANT "A"
2
1
0
1
2
3
4
5
(−)
(+)
CHARGE (ARBITRARY UNITS)

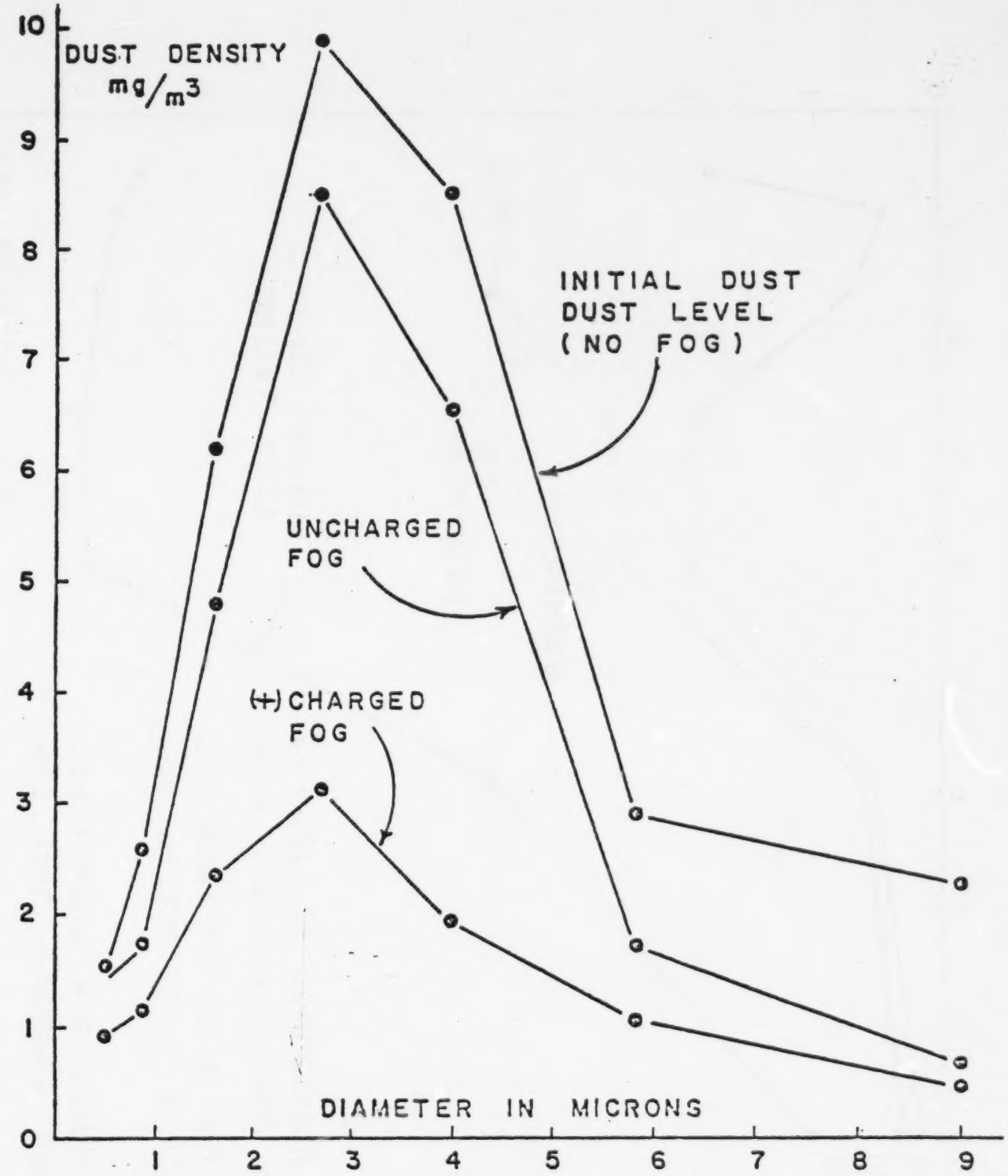

PARTICLE SIZE
MICROMETERS
INDICATES SPREAD OF DATA
DUST FROM CONCENTRATE CONVEYOR
COPPER COMPANY "A"
8
7
6
5
4
3
2
1
(-) CHARGE
10 8 6 4 2
(+) CHARGE ARBITRARY UNITS
2 4 6 8 10


8
PARTICLE SIZE
MICROMETERS
7
6
5
4
3
2
1
CEMENT COMPANY "A"
DUST FROM QUARRY SURGE
STORAGE CONVEYOR
INDICATES SPREAD OF DATA
(−) CHARGE
(+) CHARGE
5 4 3 2 1 2 3 4 5

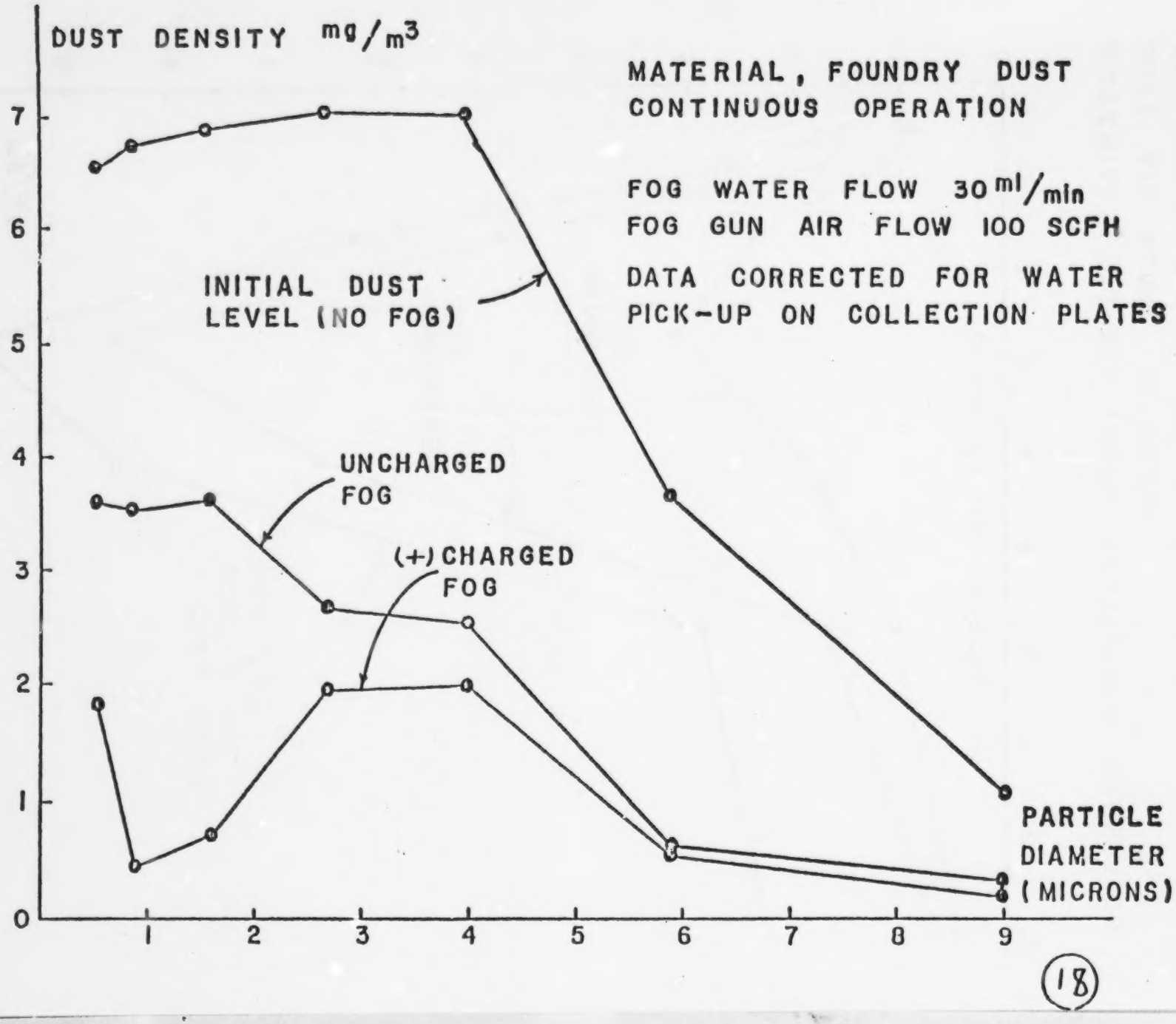

PARTICLE SIZE
MICROMETERS
8
7
6
5
4
3
2
1
CEMENT COMPANY "A"
CLINKER DUST FROM BELT TO STORAGE AREA
INDICATES SPREAD OF DATA
(−) CHARGE
(+) CHARGE
5 4 3 2 1
1 3 4 5 6

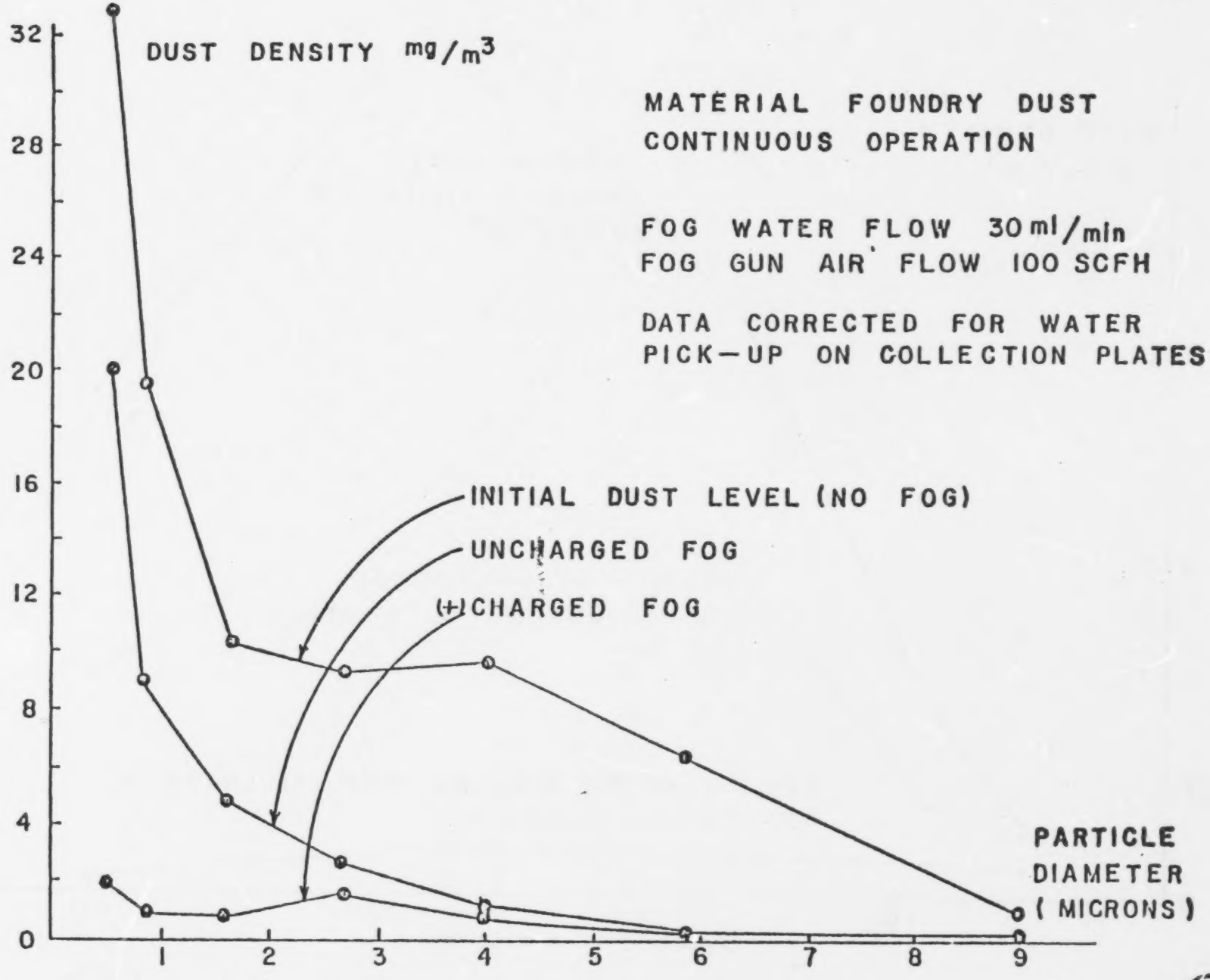

ABOVE 11
PARTICLE SIZE
MICROMETERS
6
4
2
0
5 RUNS
(SILICA SAND)
INDICATES SPREAD
OF THE DATA
12
10
8
6
4
2
0
2
4
6
(-)
CHARGE (ARBITRARY UNITS)
(+)
15

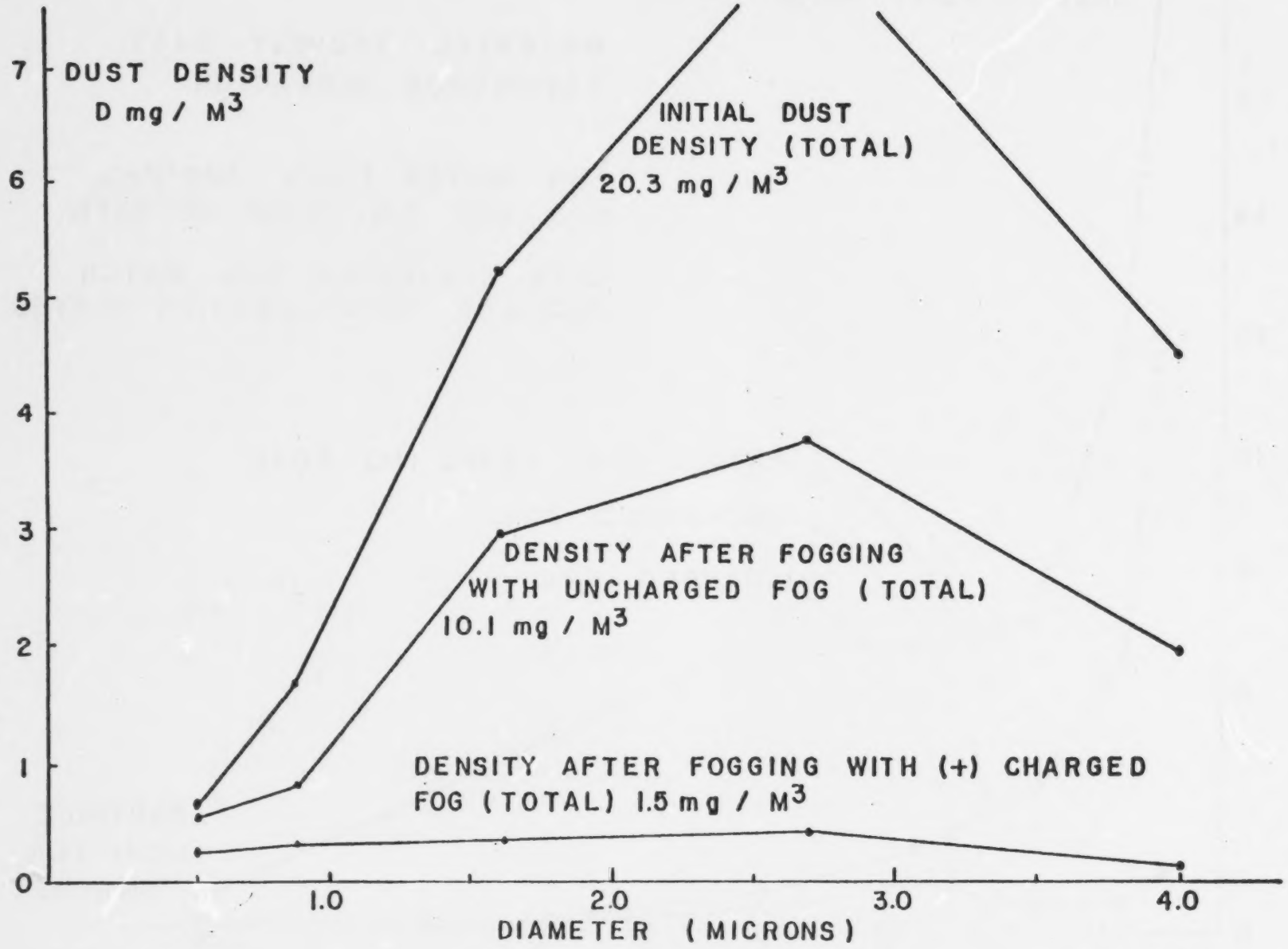

CHARGE UNITS
(ARBITRARY)
8
6
4
2
0
2
4
6
8
+
−
AVERAGE OF 3 TESTS
* RESPIRATORY PENETRATION
SILICA DUST
* PHARYNX
4.7 — 7.0 u
* SECONDARY BRONCHI
2.1 — 3.3 u
* ALVEOLI
0.65 — 1.1 u
1
2
3
4
5
6
7
8
9
10
11
t (MINUTES)



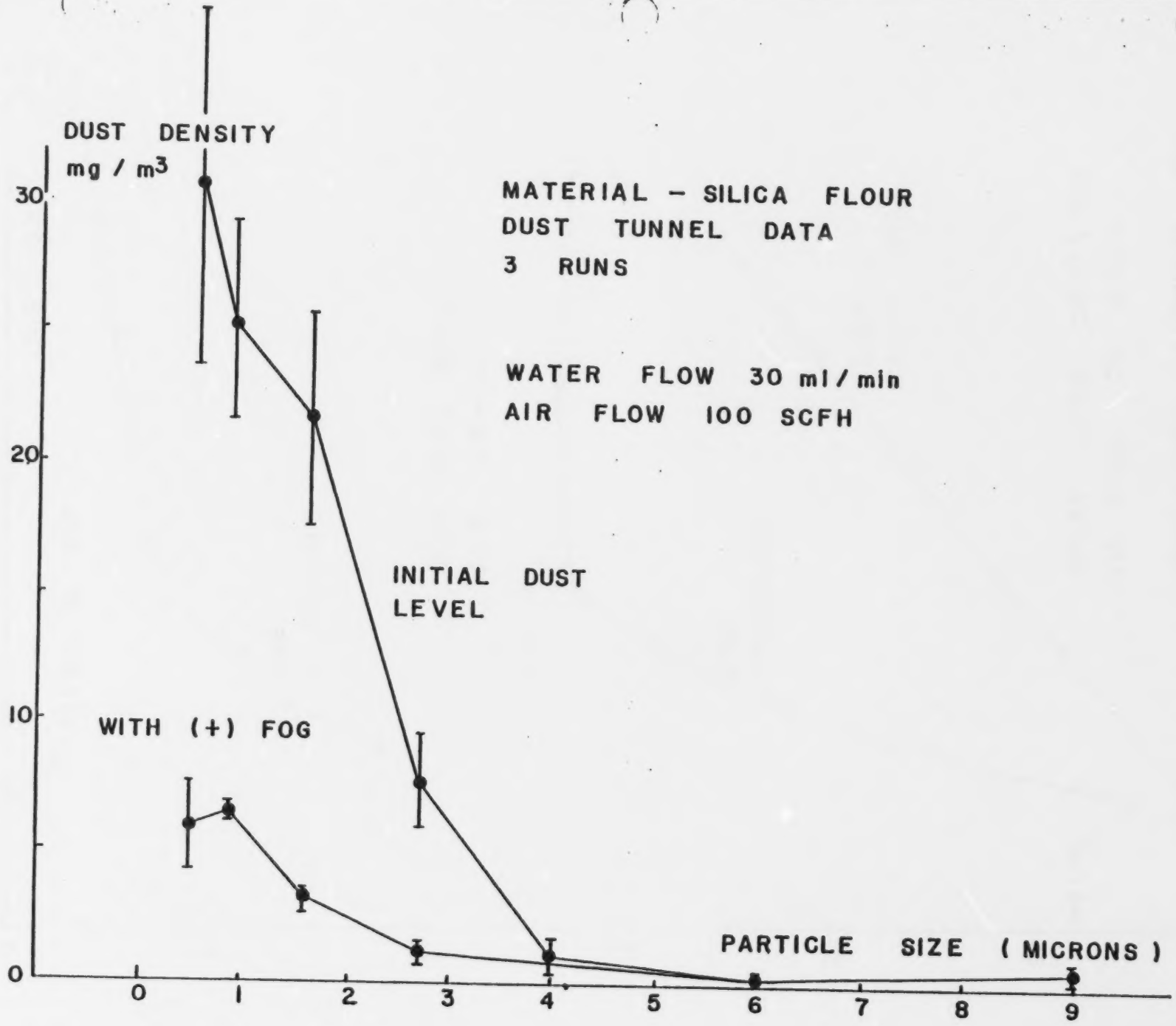
MATERIAL (FOUNDRY DUST) CONTINUOUS OPERATION
DUST AIR FLOW 50 SCFH
FOG WATER FLOW 30 ml/min (0.475 gal/hr)

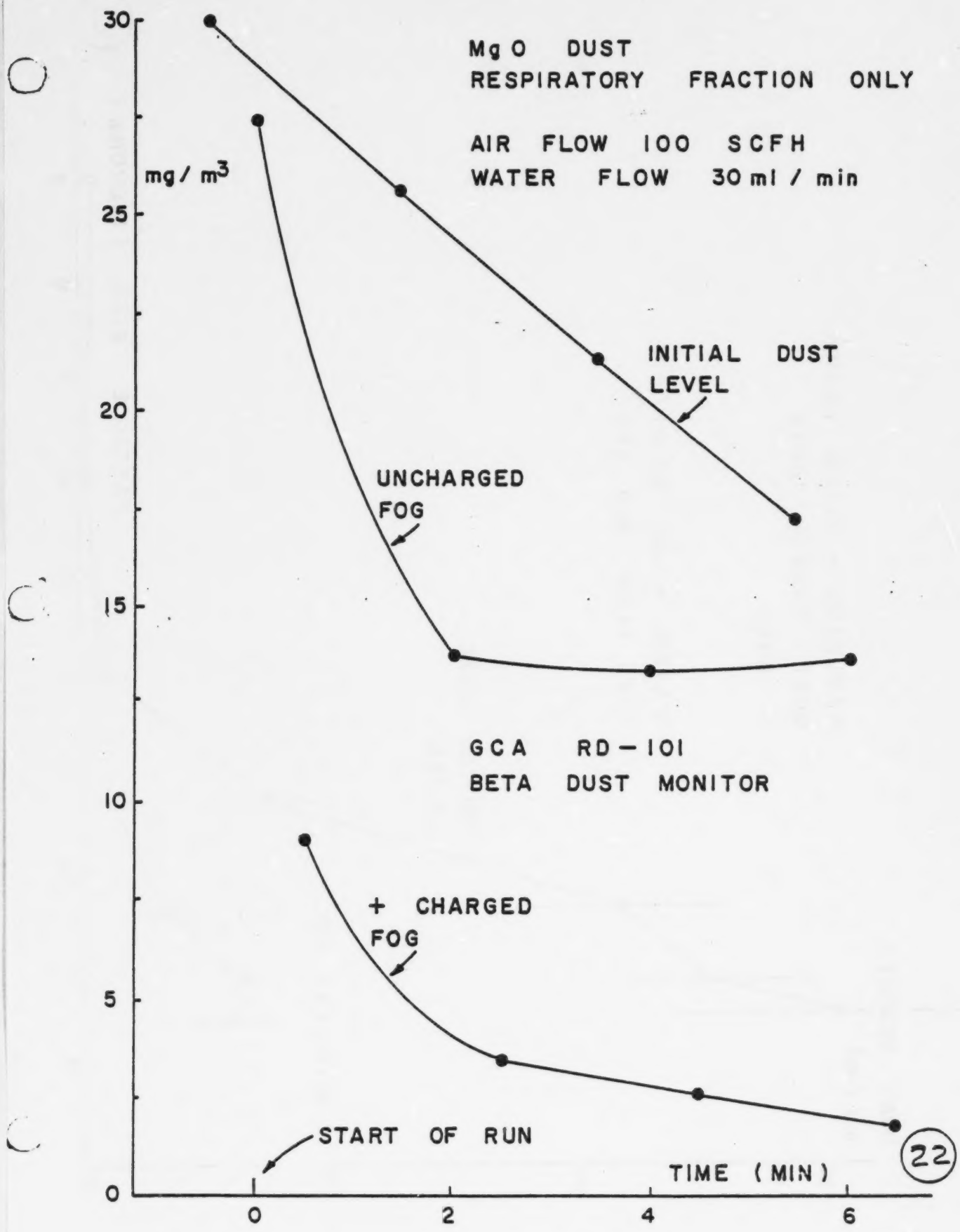

DUST DENSITY mg/m3
MATERIAL, FOUNDRY DUST
CONTINUOUS OPERATION
FOG WATER FLOW 30 ml/min
FOG GUN AIR FLOW 100 SCFH
DATA CORRECTED FOR WATER PICK-UP ON COLLECTION PLATES
INITIAL DUST LEVEL (NO FOG)
UNCHARGED FOG
(+) CHARGED FOG
PARTICLE DIAMETER (MICRONS)
0
1
2
3
4
5
6
7
8
9

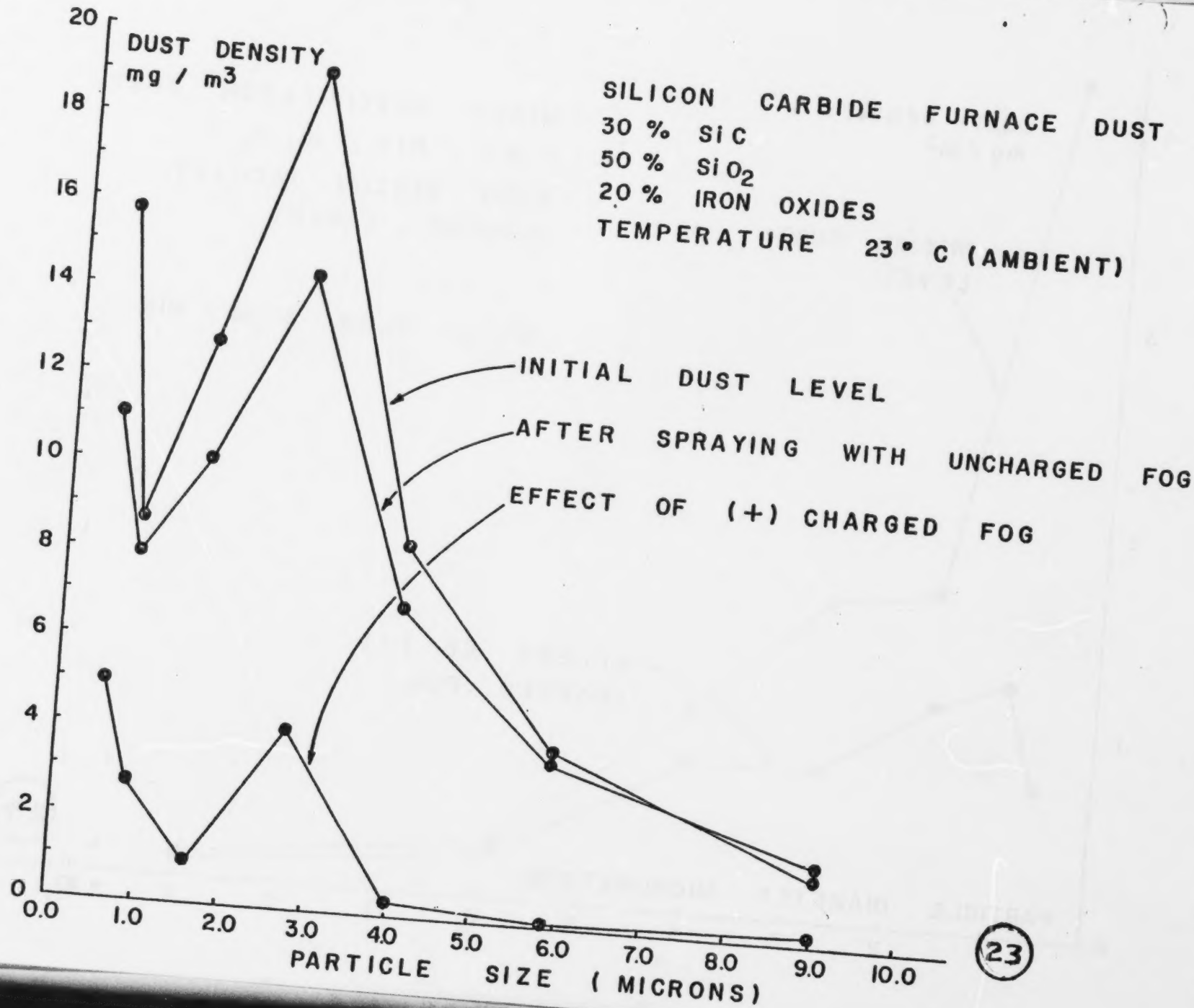

DUST DENSITY mg/m3
32
28
24
20
16
12
8
4
0
1
2
3
4
5
6
7
8
9
MATERIAL FOUNDRY DUST
CONTINUOUS OPERATION
FOG WATER FLOW 30 ml/min
FOG GUN AIR FLOW 100 SCFH
DATA CORRECTED FOR WATER
PICK-UP ON COLLECTION PLATES
INITIAL DUST LEVEL (NO FOG)
UNCHARGED FOG
(+)CHARGED FOG
PARTICLE
DIAMETER
(MICRONS)

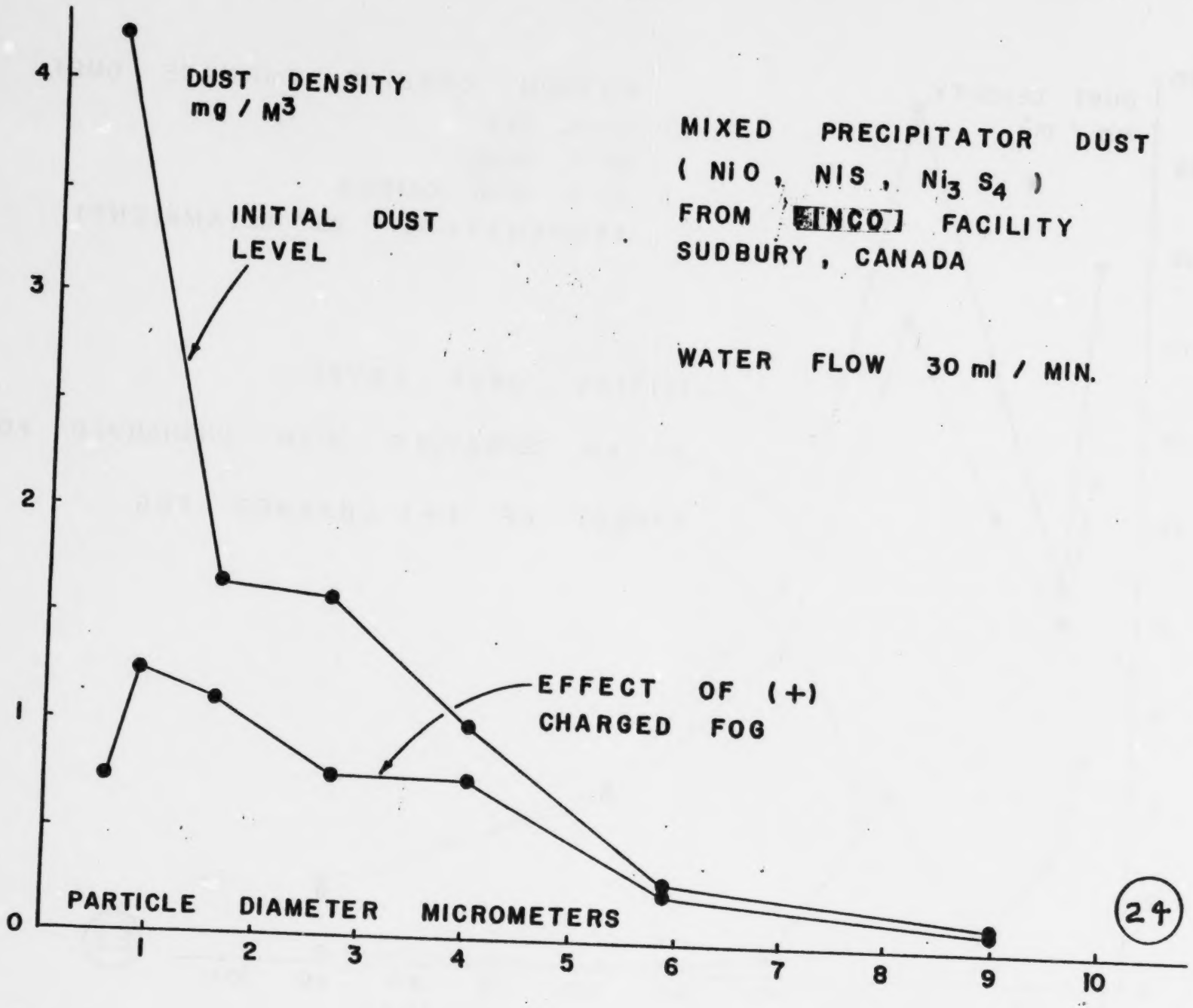


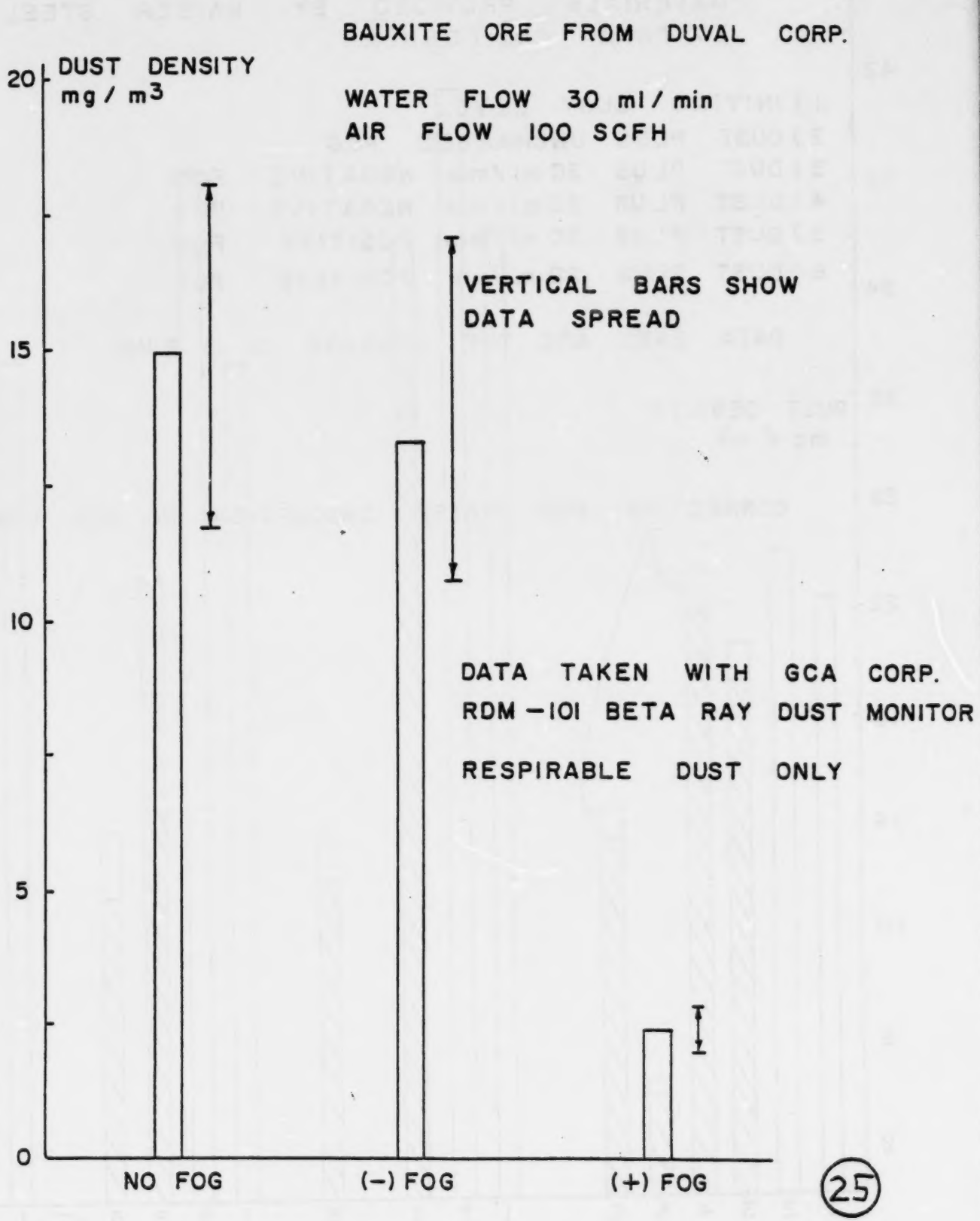
DUST DENSITY VS SIZE BEFORE AND AFTER FOGGING
FOG DENSITY 2.4 ml / M3 (SILICA SAND)

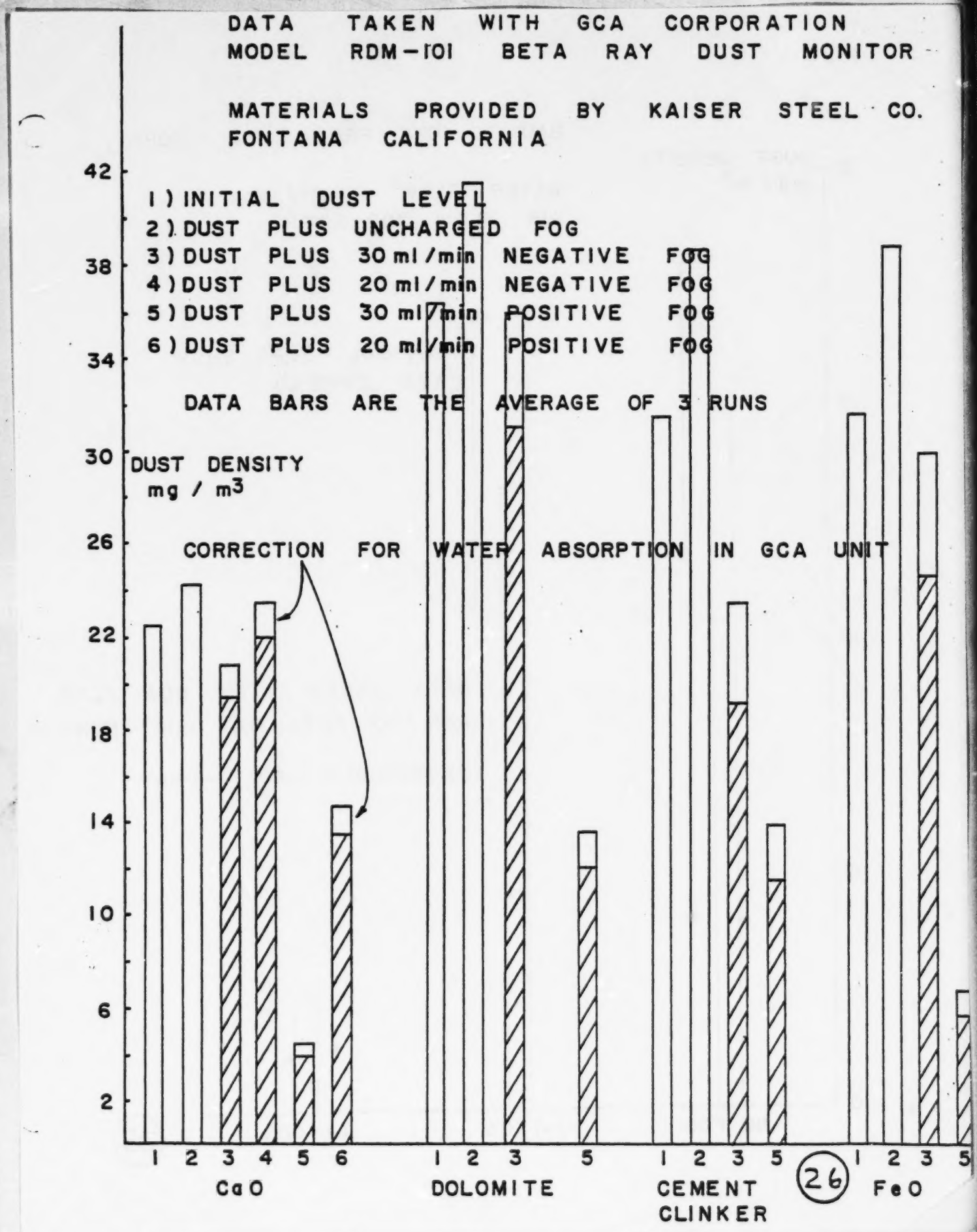

DUST DENSITY
mg / m3
30
20
10
0
MATERIAL – SILICA FLOUR
DUST TUNNEL DATA
3 RUNS
WATER FLOW 30 ml / min
AIR FLOW 100 SCFH
INITIAL DUST LEVEL
WITH (+) FOG
PARTICLE SIZE (MICRONS)
0
1
2
3
4
5
6
7
8
9

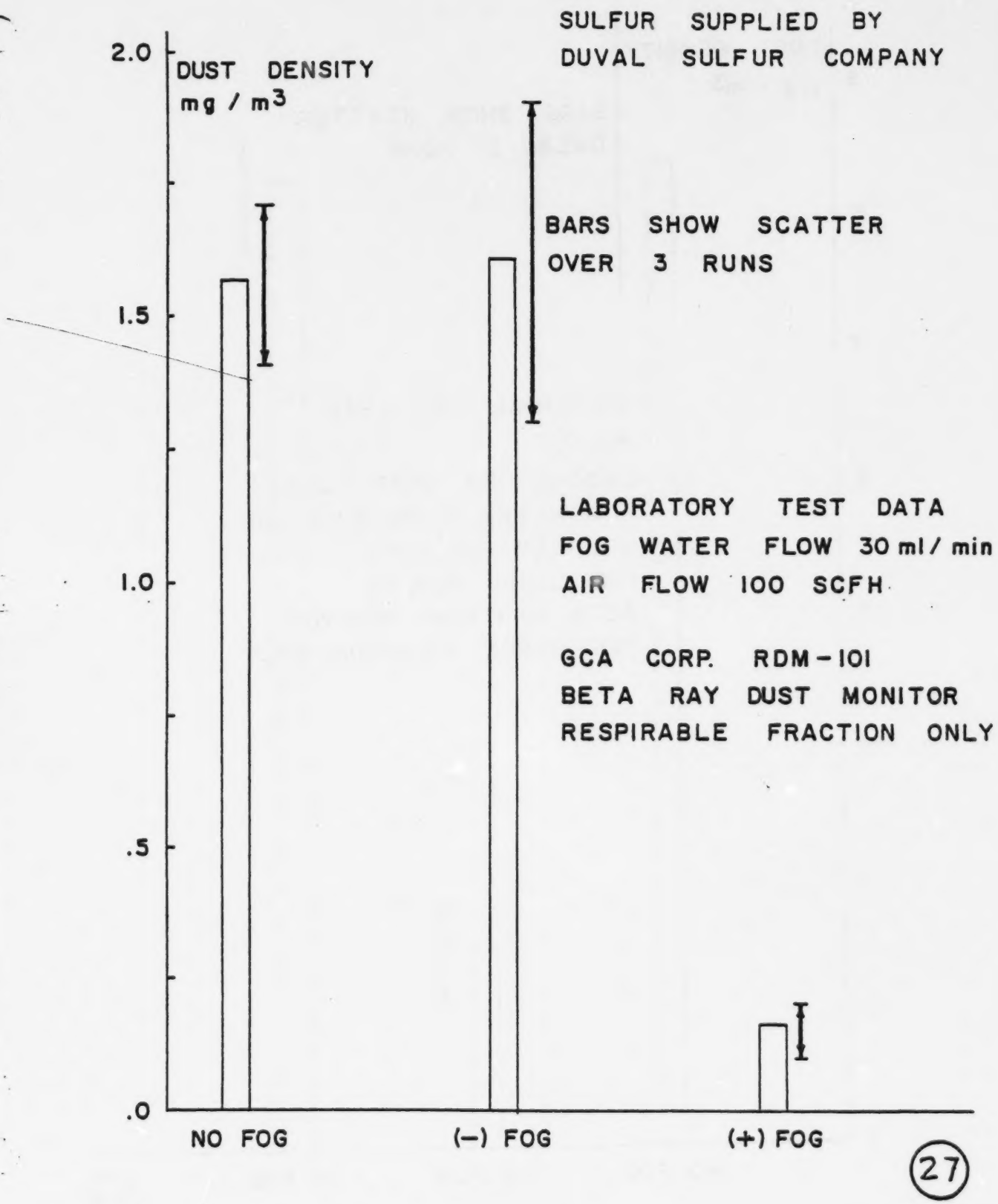

Mg O DUST
RESPIRATORY FRACTION ONLY
AIR FLOW 100 SCFH
WATER FLOW 30 ml / min
mg / m3
30
25
20
15
10
5
0
INITIAL DUST LEVEL
UNCHARGED FOG
GCA RD-101
BETA DUST MONITOR
+ CHARGED FOG
START OF RUN
TIME (MIN)
0
2
4
6

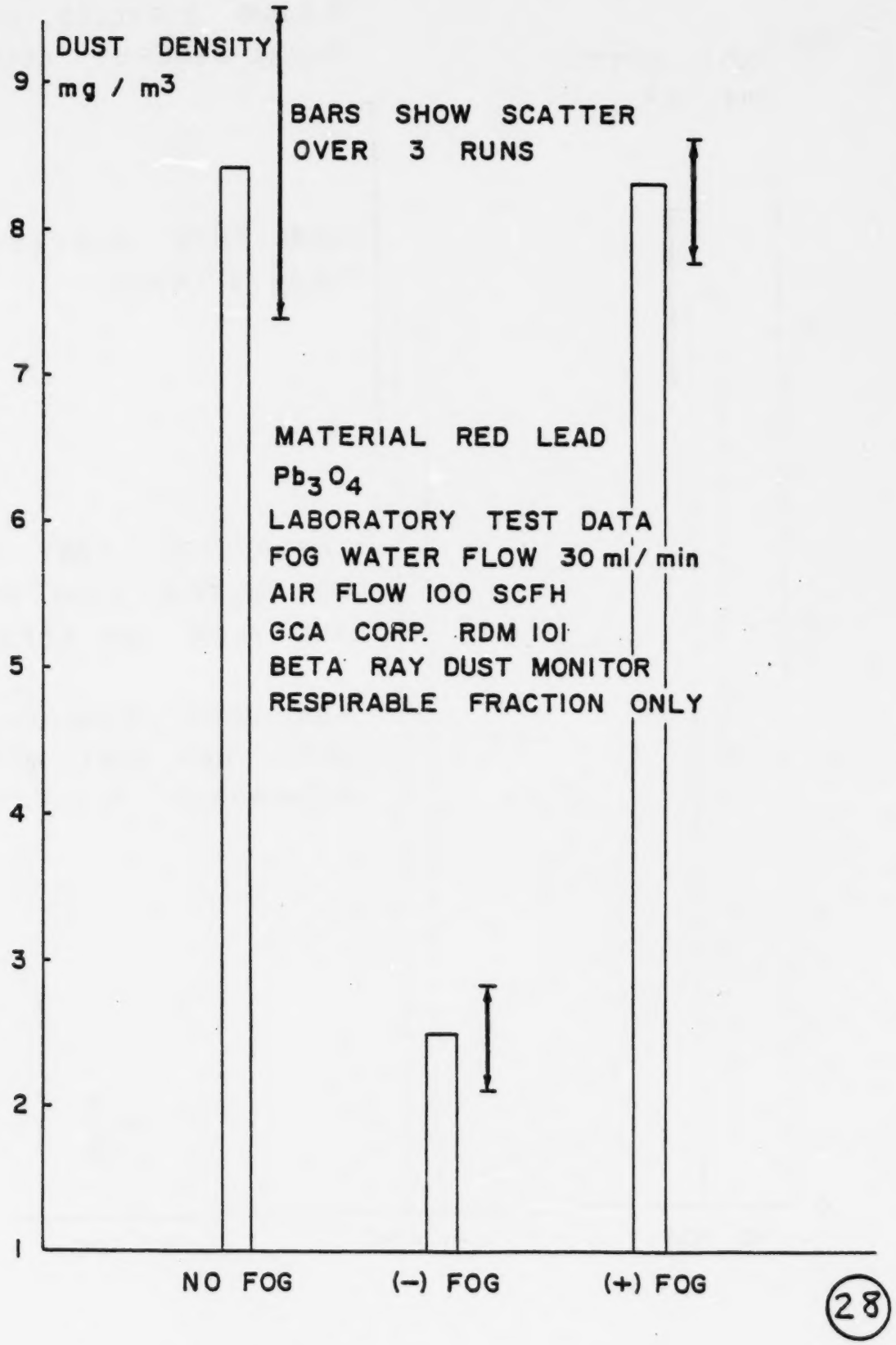

DUST DENSITY
mg / m3
20
18
16
14
12
10
8
6
4
2
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
PARTICLE SIZE (MICRONS)
SILICON CARBIDE FURNACE DUST
30 % SiC
50 % SiO2
20 % IRON OXIDES
TEMPERATURE 23° C (AMBIENT)
INITIAL DUST LEVEL
AFTER SPRAYING WITH UNCHARGED FOG
EFFECT OF (+) CHARGED FOG

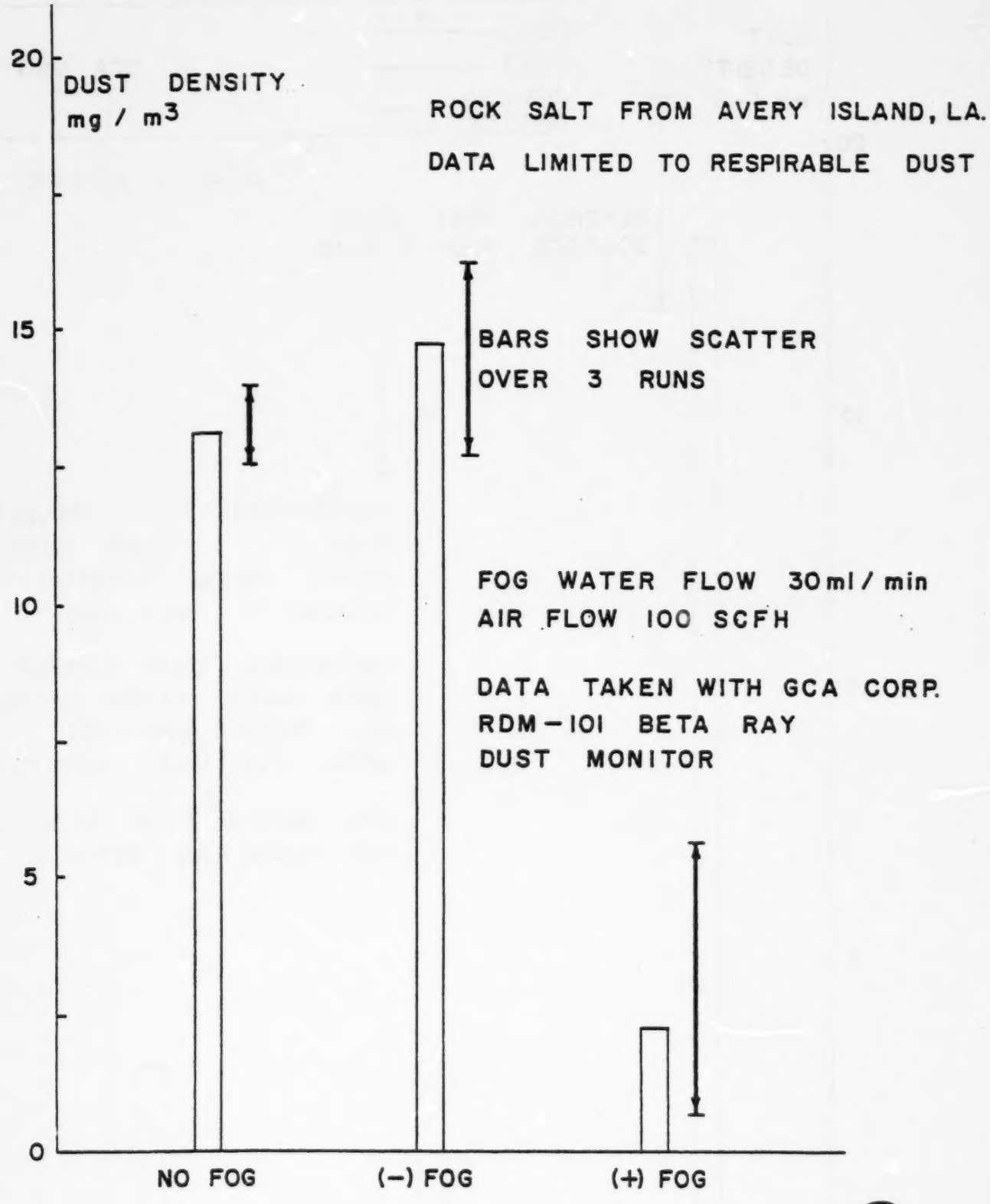

DUST DENSITY
mg / M3
MIXED PRECIPITATOR DUST
(NiO , NiS , Ni3 S4)
FROM INCO FACILITY
SUDBURY , CANADA
WATER FLOW 30 ml / MIN.
INITIAL DUST LEVEL
EFFECT OF (+) CHARGED FOG
PARTICLE DIAMETER MICROMETERS
0
1
2
3
4
5
6
7
8
9
10
24

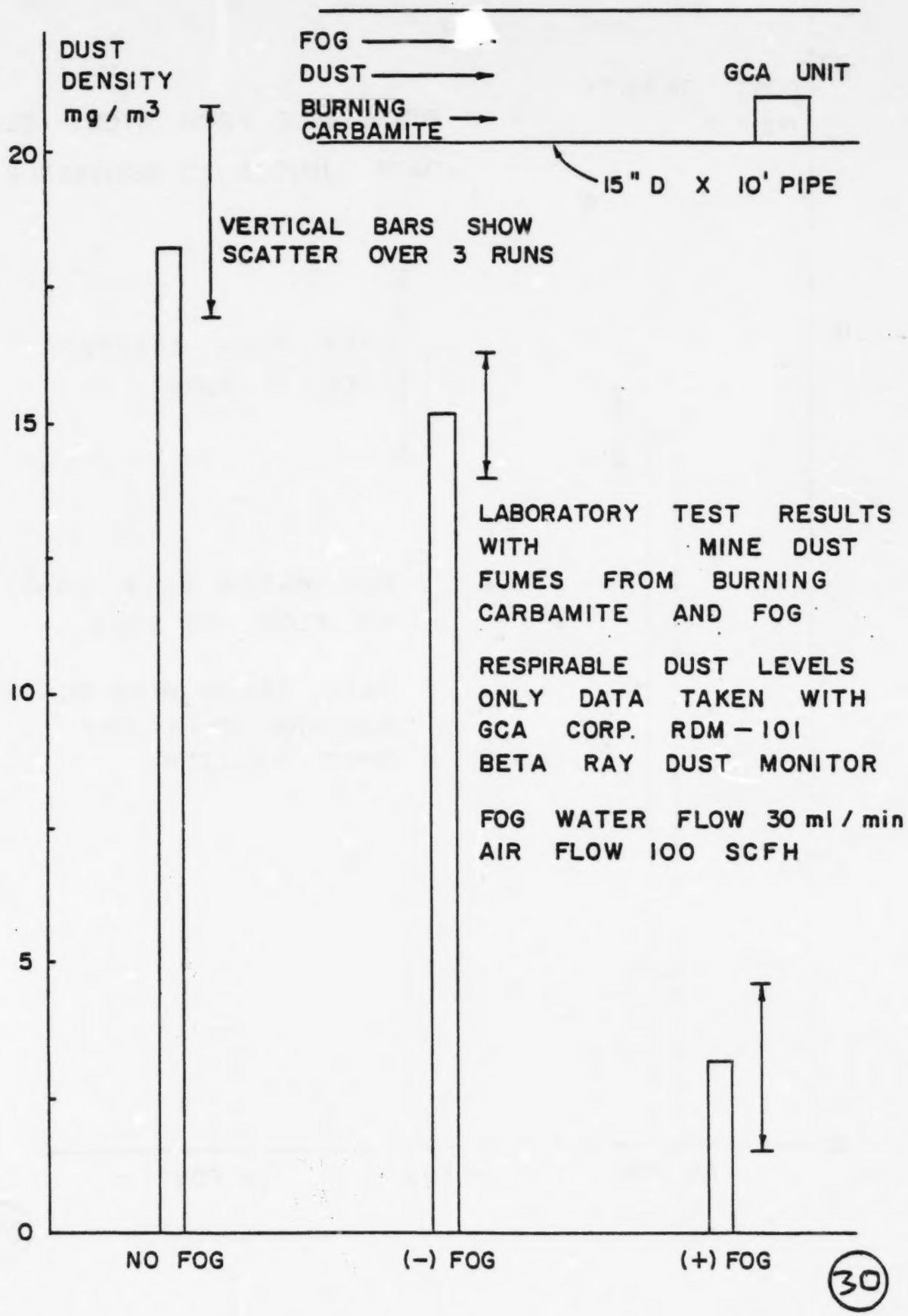

BAUXITE ORE FROM DUVAL CORP.
DUST DENSITY
mg / m3
20
15
10
5
0
WATER FLOW 30 ml / min
AIR FLOW 100 SCFH
VERTICAL BARS SHOW
DATA SPREAD
DATA TAKEN WITH GCA CORP.
RDM – 101 BETA RAY DUST MONITOR
RESPIRABLE DUST ONLY
NO FOG
(–) FOG
(+) FOG

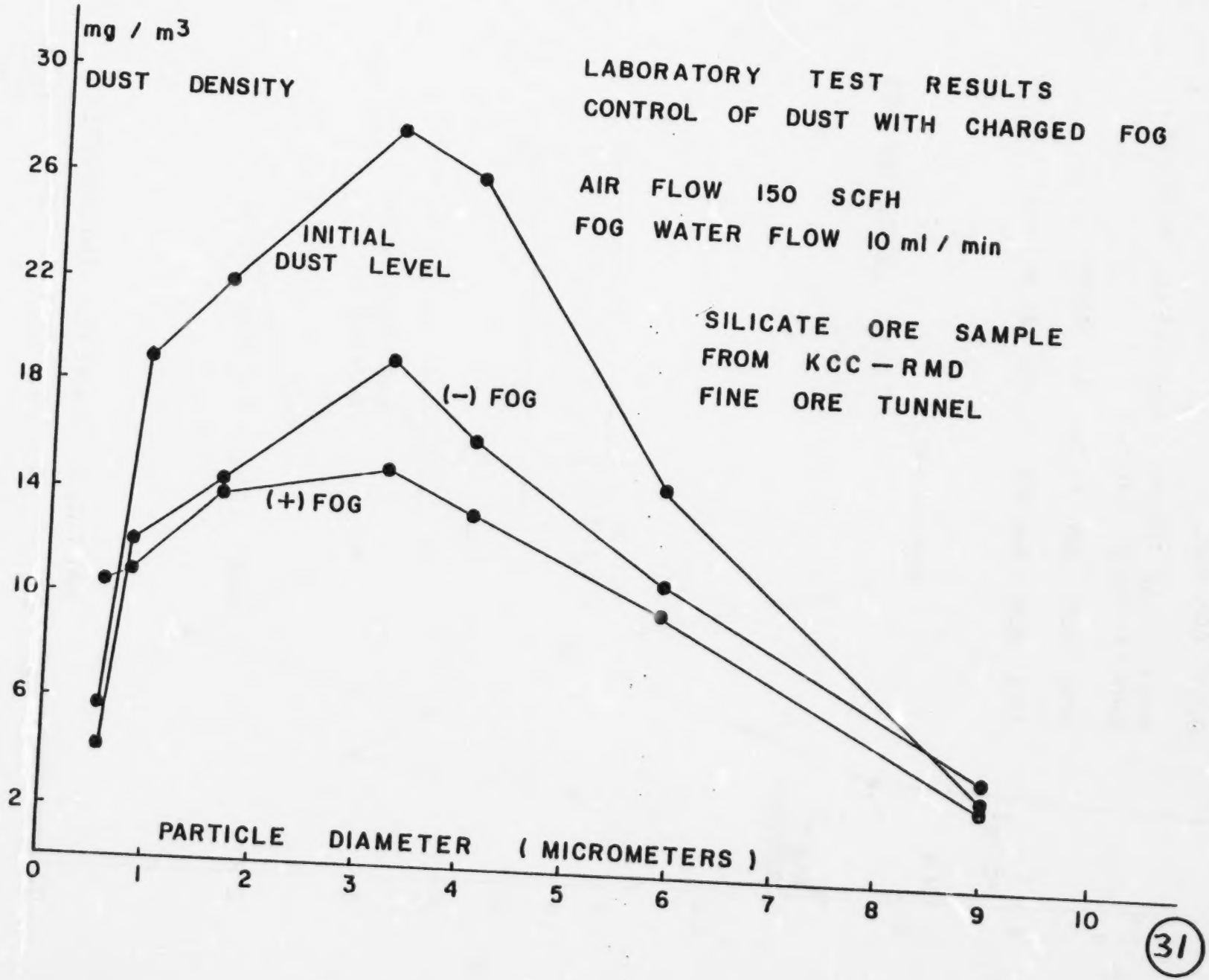

DATA TAKEN WITH GCA CORPORATION
MODEL RDM-101 BETA RAY DUST MONITOR
MATERIALS PROVIDED BY KAISER STEEL CO.
FONTANA CALIFORNIA
1) INITIAL DUST LEVEL
2) DUST PLUS UNCHARGED FOG
3) DUST PLUS 30 ml/min NEGATIVE FOG
4) DUST PLUS 20 ml/min NEGATIVE FOG
5) DUST PLUS 30 ml/min POSITIVE FOG
6) DUST PLUS 20 ml/min POSITIVE FOG
DATA BARS ARE THE AVERAGE OF 3 RUNS
DUST DENSITY
mg / m3
CORRECTION FOR WATER ABSORPTION IN GCA UNIT
42
38
34
30
26
22
18
14
10
6
2
1 2 3 4 5 6
CaO
1 2 3 5
DOLOMITE
1 2 3 5
CEMENT CLINKER
1 2 3 5
FeO


SULFUR SUPPLIED BY
DUVAL SULFUR COMPANY
2.0
DUST DENSITY
mg / m3
BARS SHOW SCATTER
OVER 3 RUNS
1.5
LABORATORY TEST DATA
FOG WATER FLOW 30 ml / min
AIR FLOW 100 SCFH
1.0
GCA CORP. RDM-101
BETA RAY DUST MONITOR
RESPIRABLE FRACTION ONLY
.5
.0
NO FOG
(-) FOG
(+) FOG


DUST DENSITY
mg / m3
9
8
7
6
5
4
3
2
1
BARS SHOW SCATTER
OVER 3 RUNS
MATERIAL RED LEAD
Pb3O4
LABORATORY TEST DATA
FOG WATER FLOW 30 ml / min
AIR FLOW 100 SCFH
GCA CORP. RDM 101
BETA RAY DUST MONITOR
RESPIRABLE FRACTION ONLY
NO FOG
(-) FOG
(+) FOG


20
15
10
5
0
DUST DENSITY
mg / m3
ROCK SALT FROM AVERY ISLAND, LA.
DATA LIMITED TO RESPIRABLE DUST
BARS SHOW SCATTER
OVER 3 RUNS
FOG WATER FLOW 30 ml / min
AIR FLOW 100 SCFH
DATA TAKEN WITH GCA CORP.
RDM-101 BETA RAY
DUST MONITOR
NO FOG
(-) FOG
(+) FOG

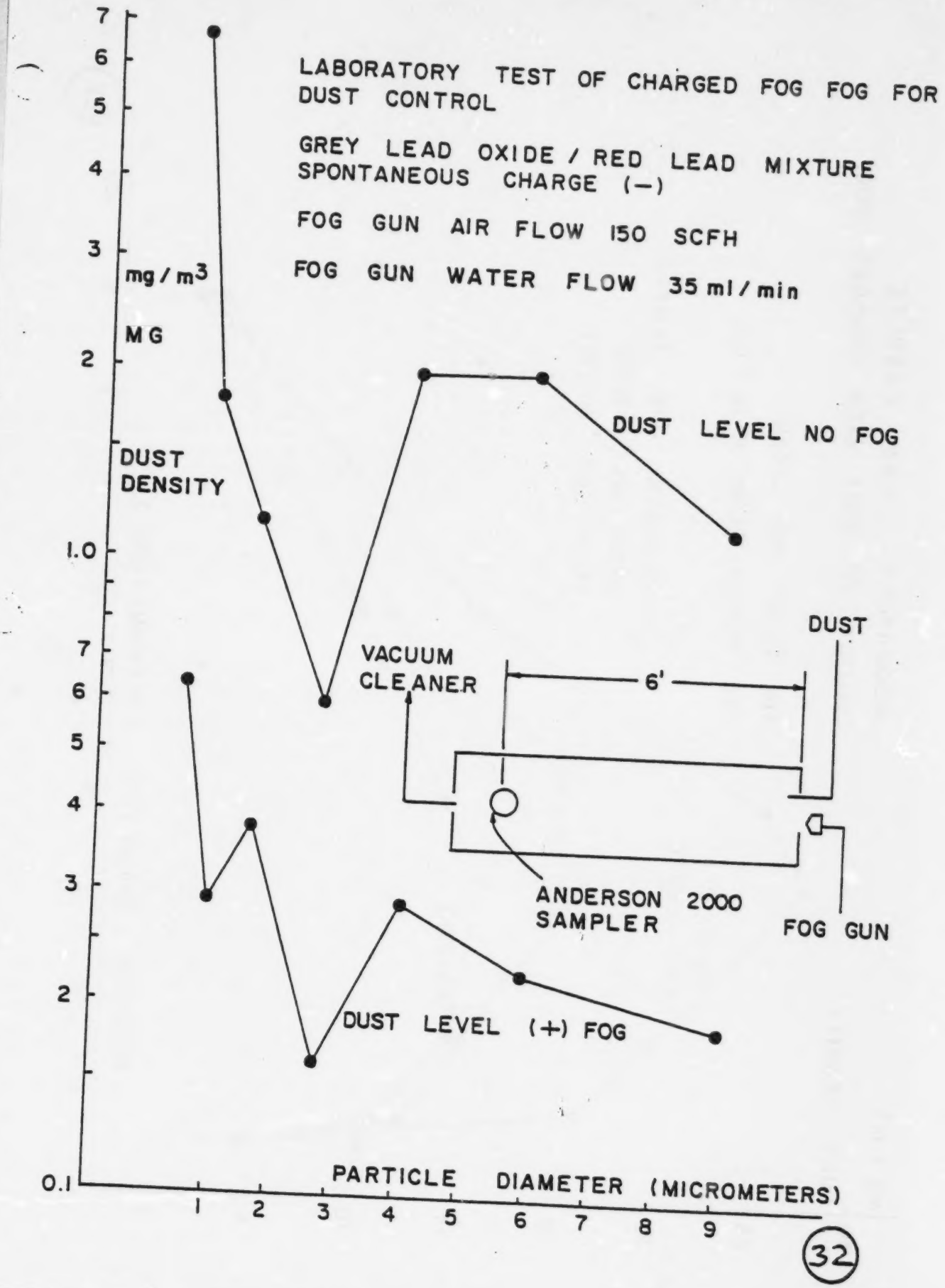

DUST
DENSITY
mg / m3
20
15
10
5
0
FOG
DUST
BURNING
CARBAMITE
GCA UNIT
15" D X 10' PIPE
VERTICAL BARS SHOW
SCATTER OVER 3 RUNS
LABORATORY TEST RESULTS
WITH MINE DUST
FUMES FROM BURNING
CARBAMITE AND FOG
RESPIRABLE DUST LEVELS
ONLY DATA TAKEN WITH
GCA CORP. RDM – 101
BETA RAY DUST MONITOR
FOG WATER FLOW 30 ml / min
AIR FLOW 100 SCFH
NO FOG
(–) FOG
(+) FOG

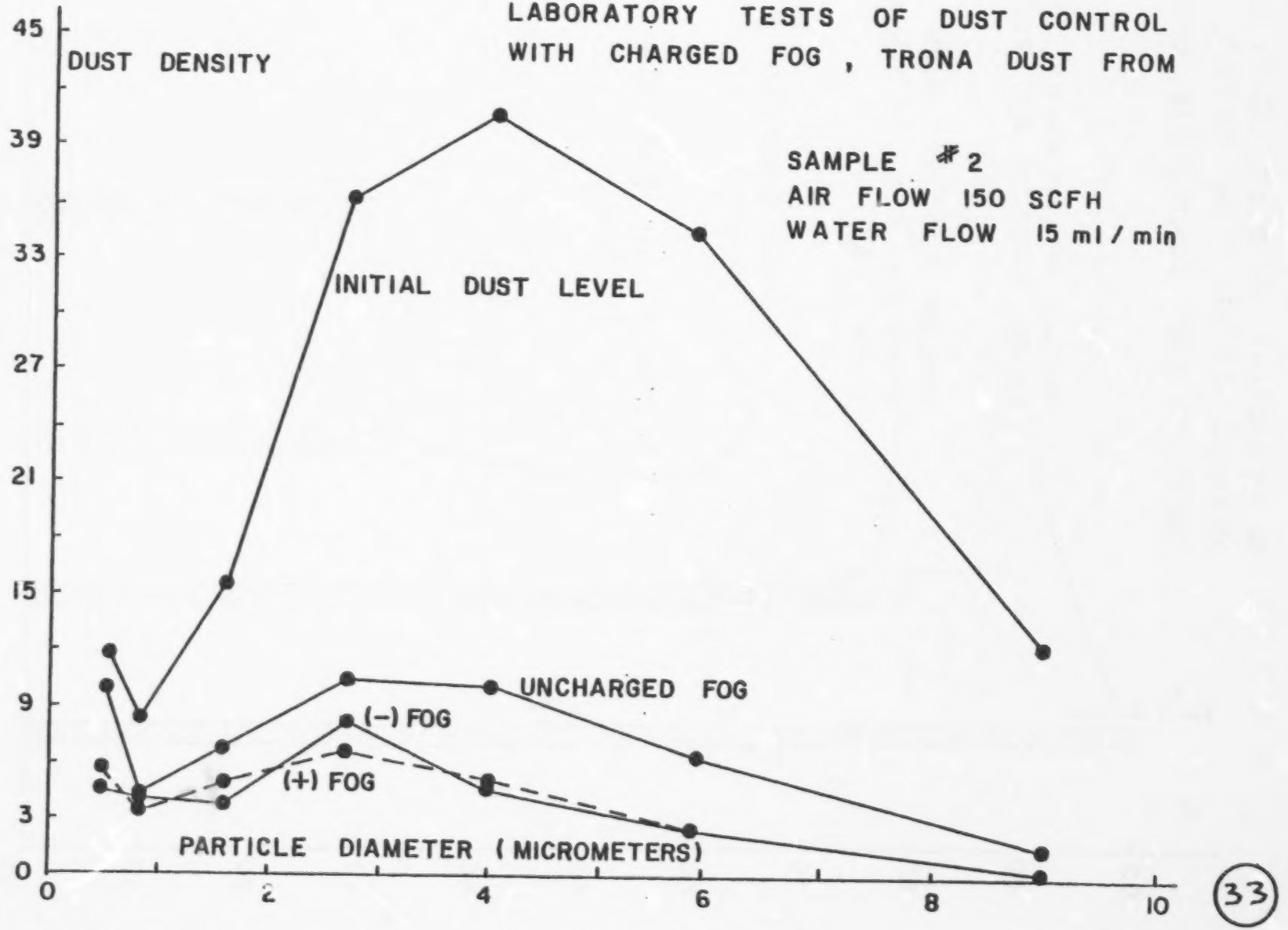


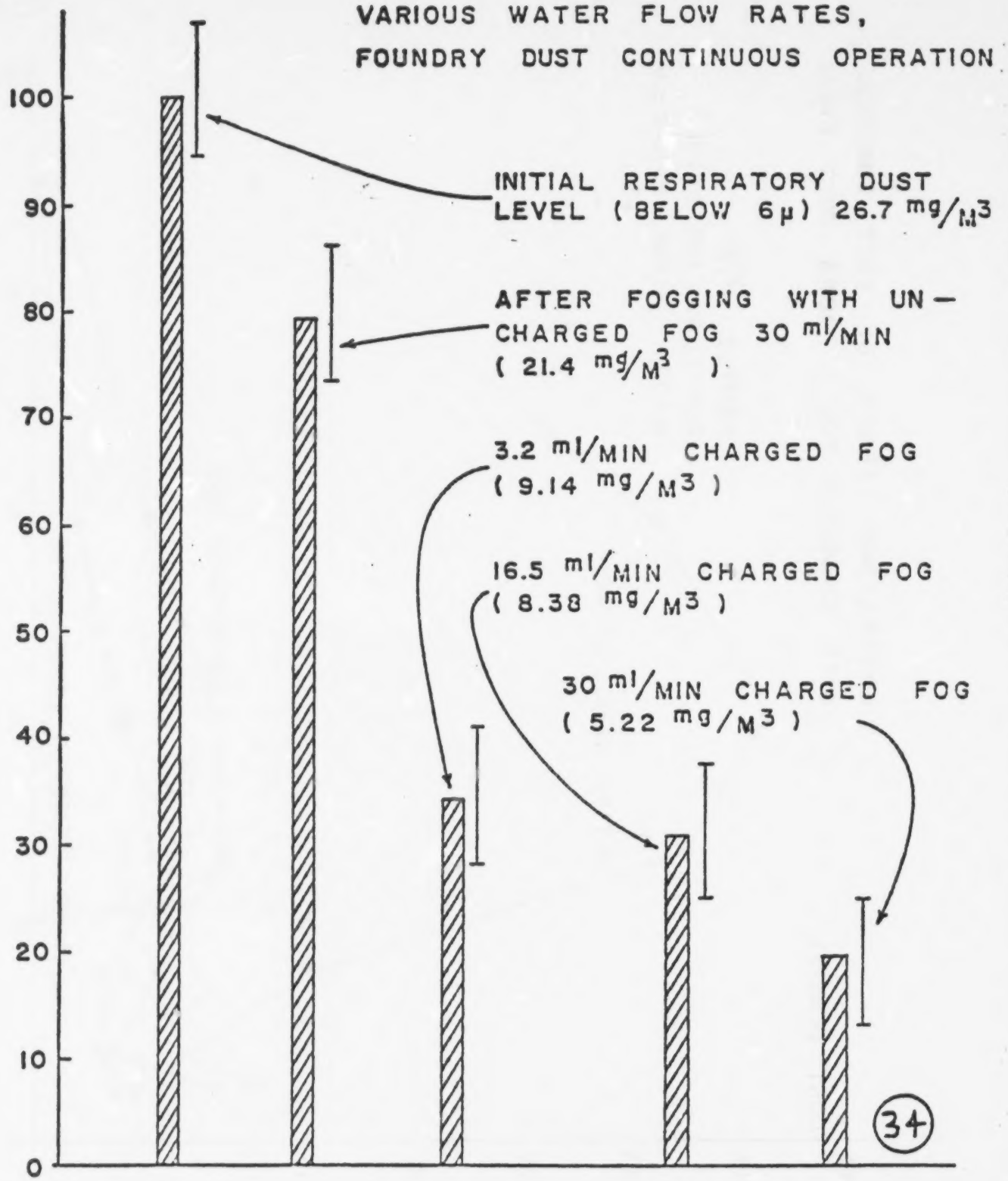
LABORATORY TEST RESULTS
CONTROL OF DUST WITH CHARGED FOG

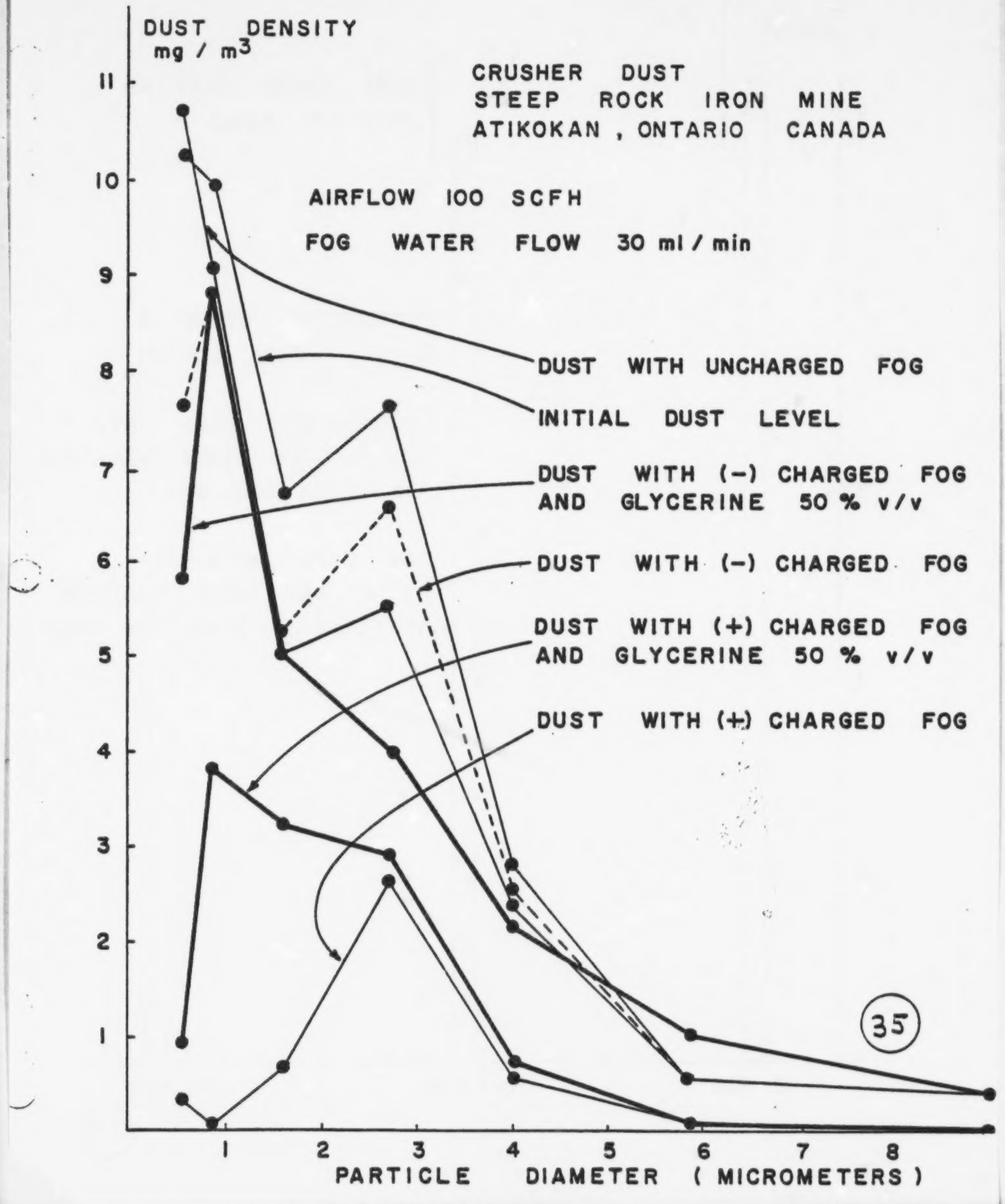
AIR FLOW 150 SCFH
FOG WATER FLOW 10 ml / min

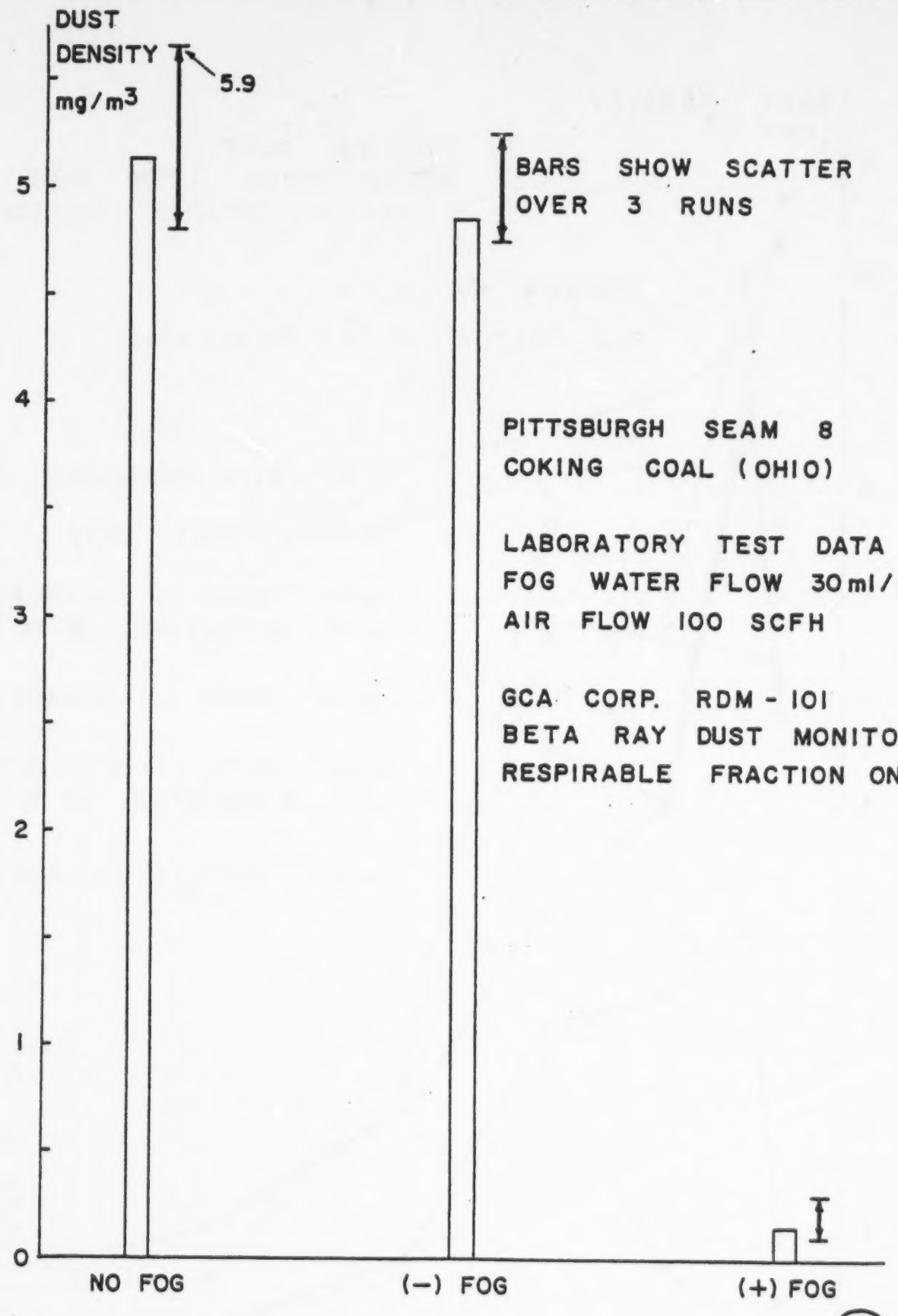
SILICATE ORE SAMPLE
FROM KCC — RMD
FINE ORE TUNNEL

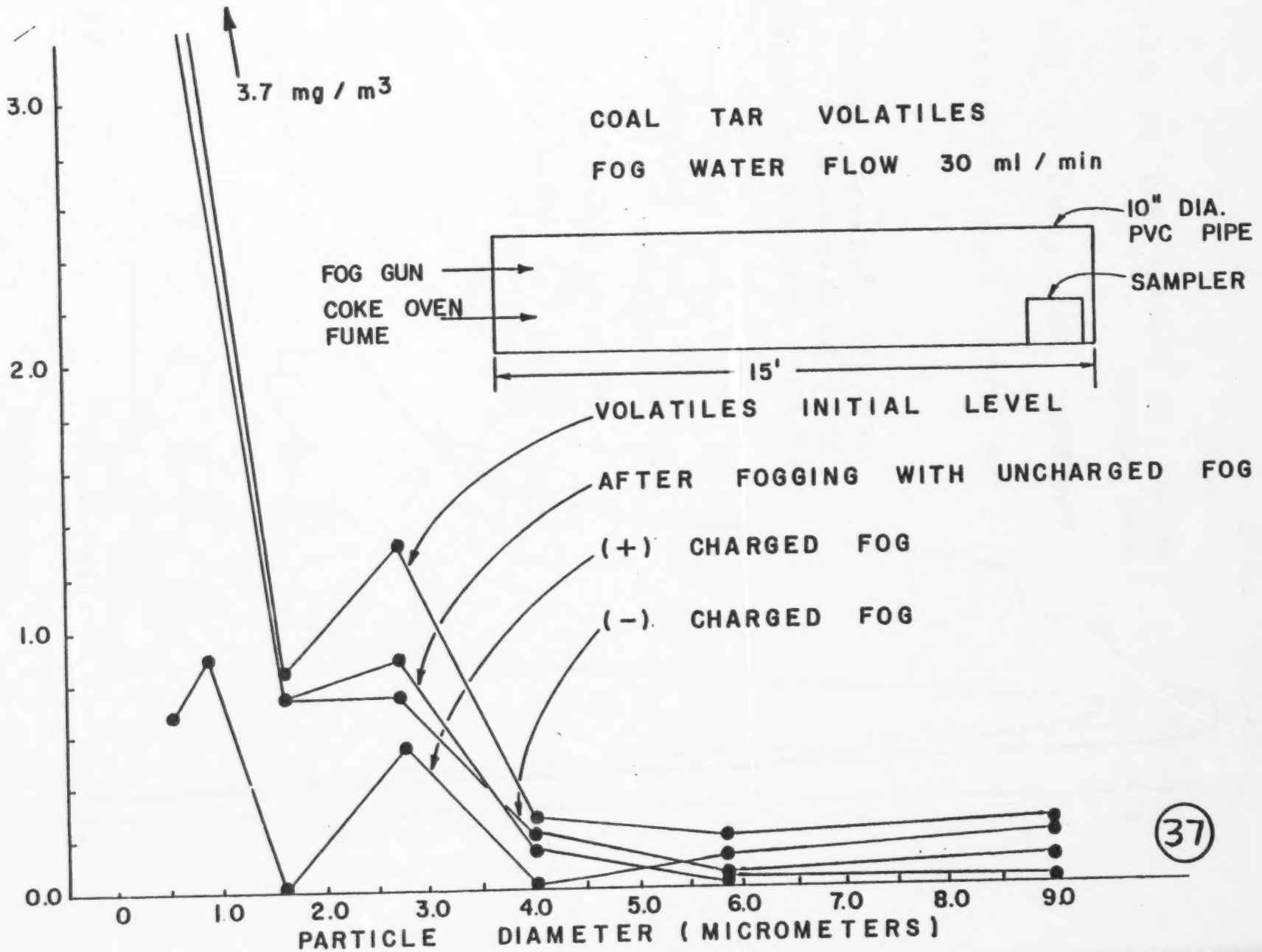

LABORATORY TEST OF CHARGED FOG FOG FOR DUST CONTROL
GREY LEAD OXIDE / RED LEAD MIXTURE
SPONTANEOUS CHARGE (−)
FOG GUN AIR FLOW 150 SCFH
FOG GUN WATER FLOW 35 ml/min
mg/m3
MG
DUST DENSITY
DUST LEVEL NO FOG
VACUUM CLEANER
6'
DUST
ANDERSON 2000 SAMPLER
FOG GUN
DUST LEVEL (+) FOG
PARTICLE DIAMETER (MICROMETERS)
7
6
5
4
3
2
1.0
0.1
1
2
3
4
5
6
7
8
9

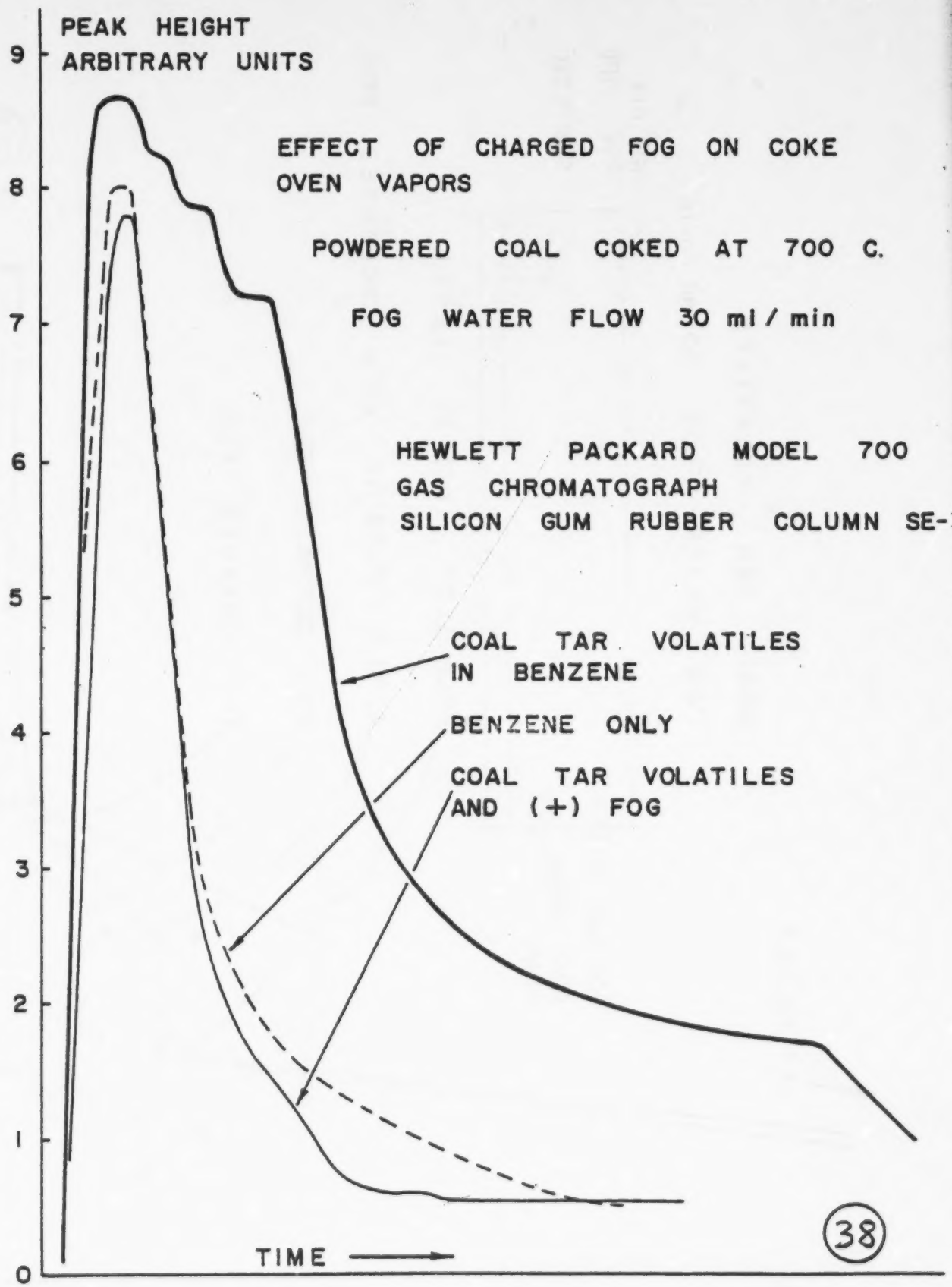

LABORATORY TESTS OF DUST CONTROL
WITH CHARGED FOG , TRONA DUST FROM
SAMPLE #2
AIR FLOW 150 SCFH
WATER FLOW 15 ml / min
DUST DENSITY
45
39
33
27
21
15
9
3
0
INITIAL DUST LEVEL
UNCHARGED FOG
(-) FOG
(+) FOG
PARTICLE DIAMETER (MICROMETERS)
0
2
4
6
8
10

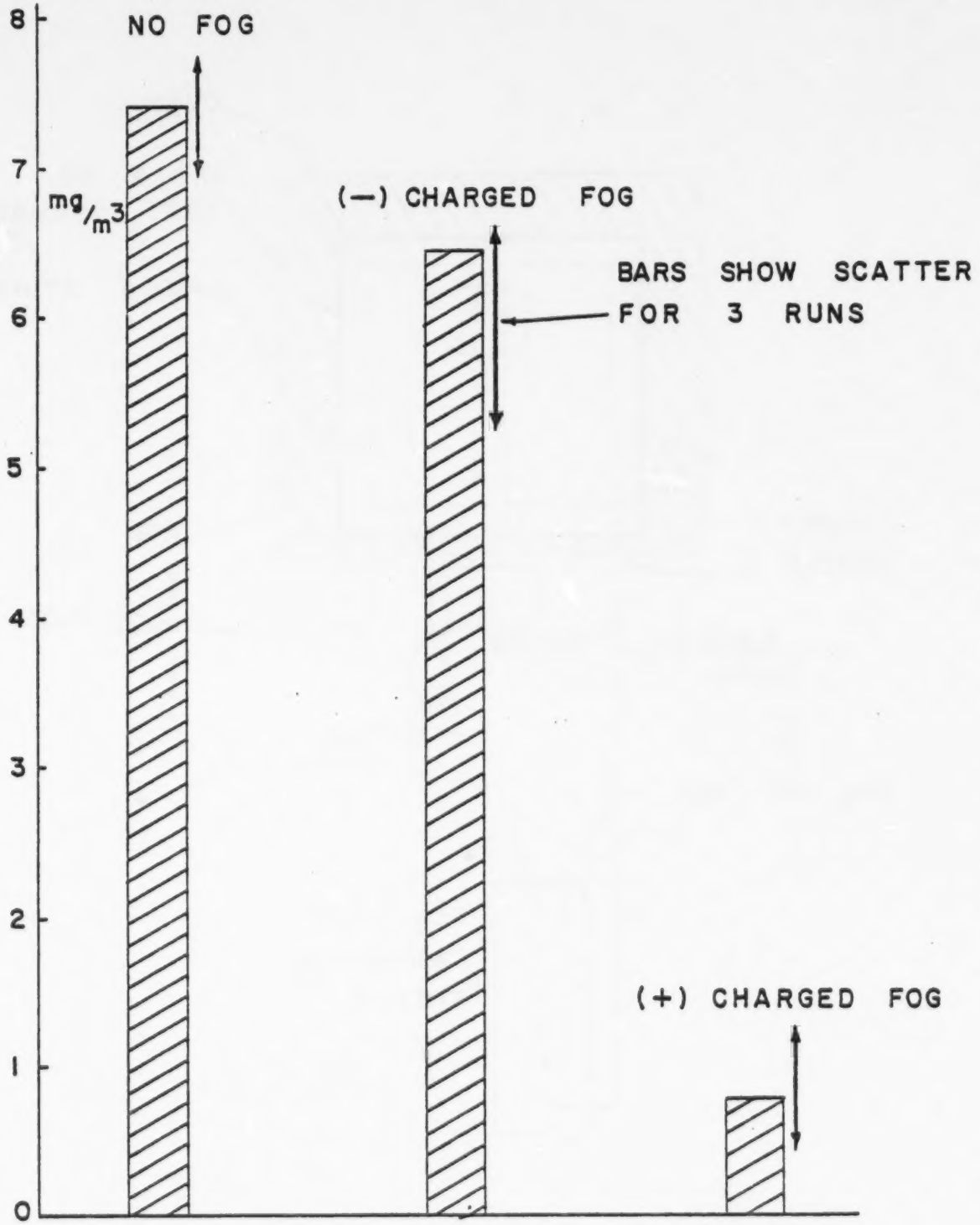

% REDUCTION IN DUST LEVEL AT VARIOUS WATER FLOW RATES, FOUNDRY DUST CONTINUOUS OPERATION
100
90
80
70
60
50
40
30
20
10
0
INITIAL RESPIRATORY DUST LEVEL (BELOW 6μ) 26.7 mg/M3
AFTER FOGGING WITH UN-CHARGED FOG 30 ml/MIN (21.4 mg/M3)
3.2 ml/MIN CHARGED FOG (9.14 mg/M3)
16.5 ml/MIN CHARGED FOG (8.38 mg/M3)
30 ml/MIN CHARGED FOG (5.22 mg/M3)
34


DUST DENSITY
mg / m3
CRUSHER DUST
STEEP ROCK IRON MINE
ATIKOKAN , ONTARIO CANADA
AIRFLOW 100 SCFH
FOG WATER FLOW 30 ml / min
DUST WITH UNCHARGED FOG
INITIAL DUST LEVEL
DUST WITH (-) CHARGED FOG AND GLYCERINE 50 % v/v
DUST WITH (-) CHARGED FOG
DUST WITH (+) CHARGED FOG AND GLYCERINE 50 % v/v
DUST WITH (+) CHARGED FOG
11
10
9
8
7
6
5
4
3
2
1
1
2
3
4
5
6
7
8
PARTICLE DIAMETER (MICROMETERS)
35

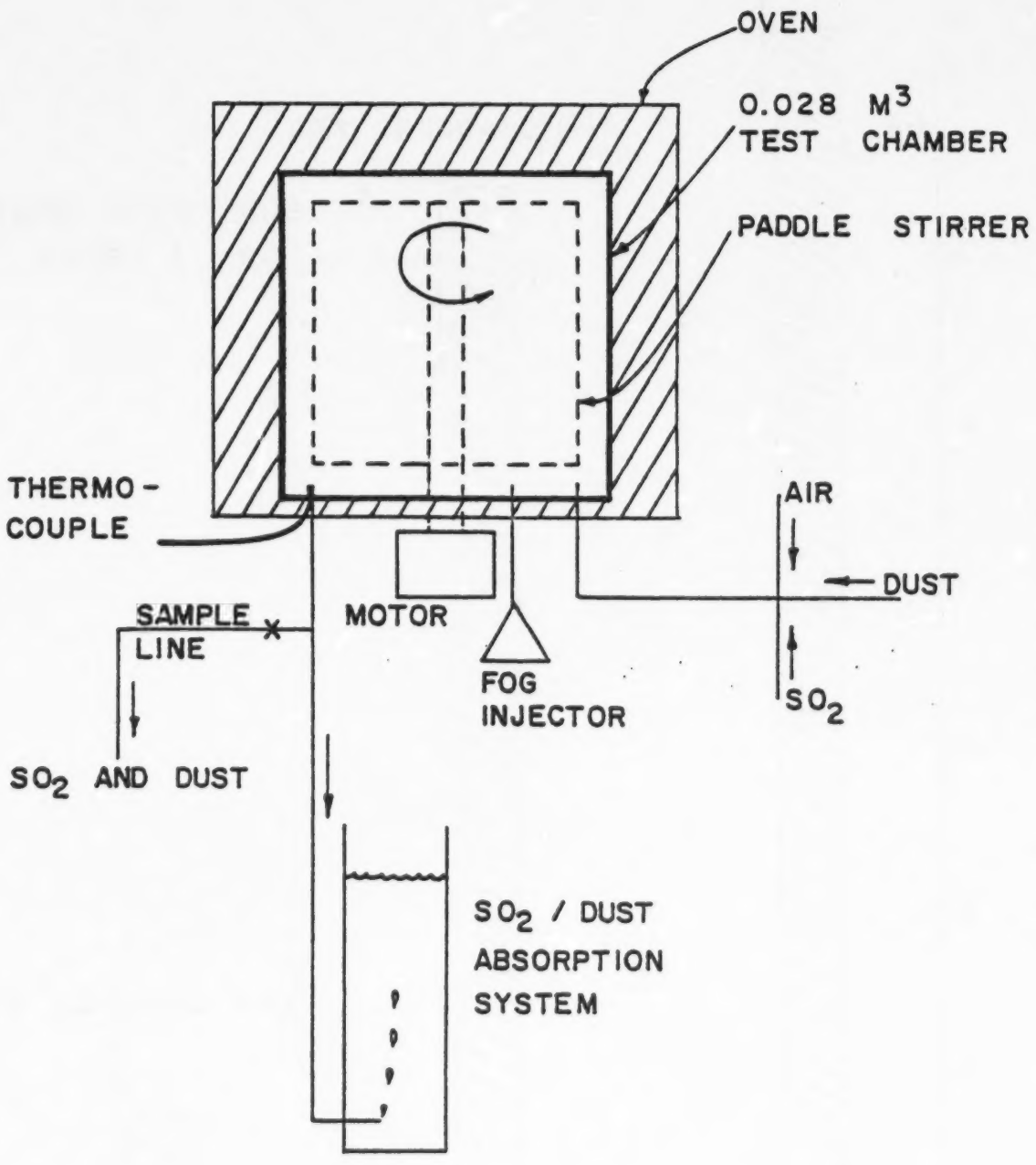

DUST
DENSITY
mg/m3
5.9
BARS SHOW SCATTER
OVER 3 RUNS
5
4
3
2
1
0
PITTSBURGH SEAM 8
COKING COAL (OHIO)
LABORATORY TEST DATA
FOG WATER FLOW 30 ml/min
AIR FLOW 100 SCFH
GCA CORP. RDM - 101
BETA RAY DUST MONITOR
RESPIRABLE FRACTION ONLY
NO FOG
(−) FOG
(+) FOG


3.7 mg / m3
COAL TAR VOLATILES
FOG WATER FLOW 30 ml / min
10" DIA. PVC PIPE
SAMPLER
FOG GUN
COKE OVEN FUME
15'
VOLATILES INITIAL LEVEL
AFTER FOGGING WITH UNCHARGED FOG
(+) CHARGED FOG
(-) CHARGED FOG
3.0
2.0
1.0
0.0
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
PARTICLE DIAMETER (MICROMETERS)

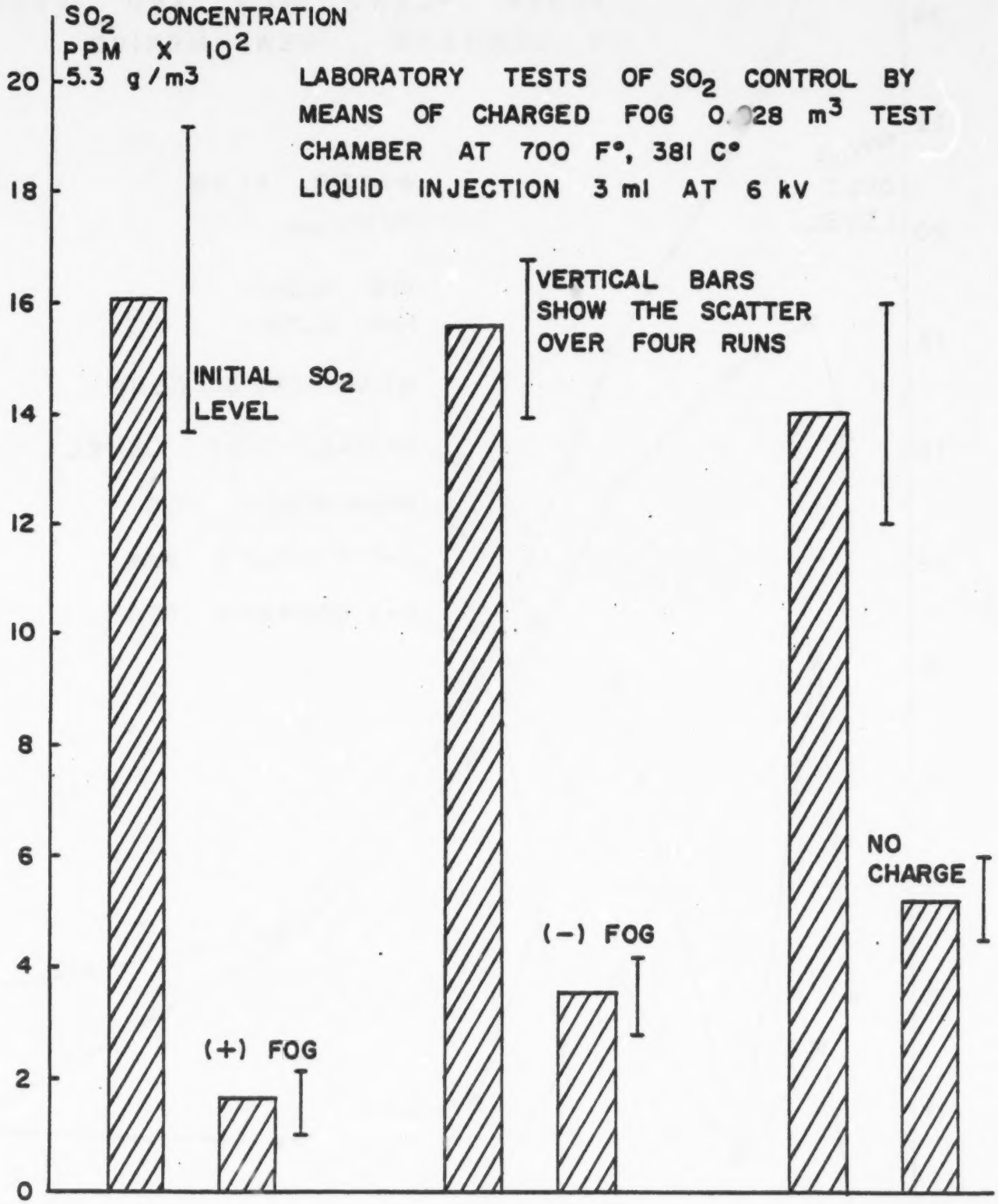

PEAK HEIGHT
ARBITRARY UNITS
9
8
7
6
5
4
3
2
1
0
EFFECT OF CHARGED FOG ON COKE OVEN VAPORS
POWDERED COAL COKED AT 700 C.
FOG WATER FLOW 30 ml / min
HEWLETT PACKARD MODEL 700
GAS CHROMATOGRAPH
SILICON GUM RUBBER COLUMN SE-30
COAL TAR VOLATILES IN BENZENE
BENZENE ONLY
COAL TAR VOLATILES AND (+) FOG
TIME
38

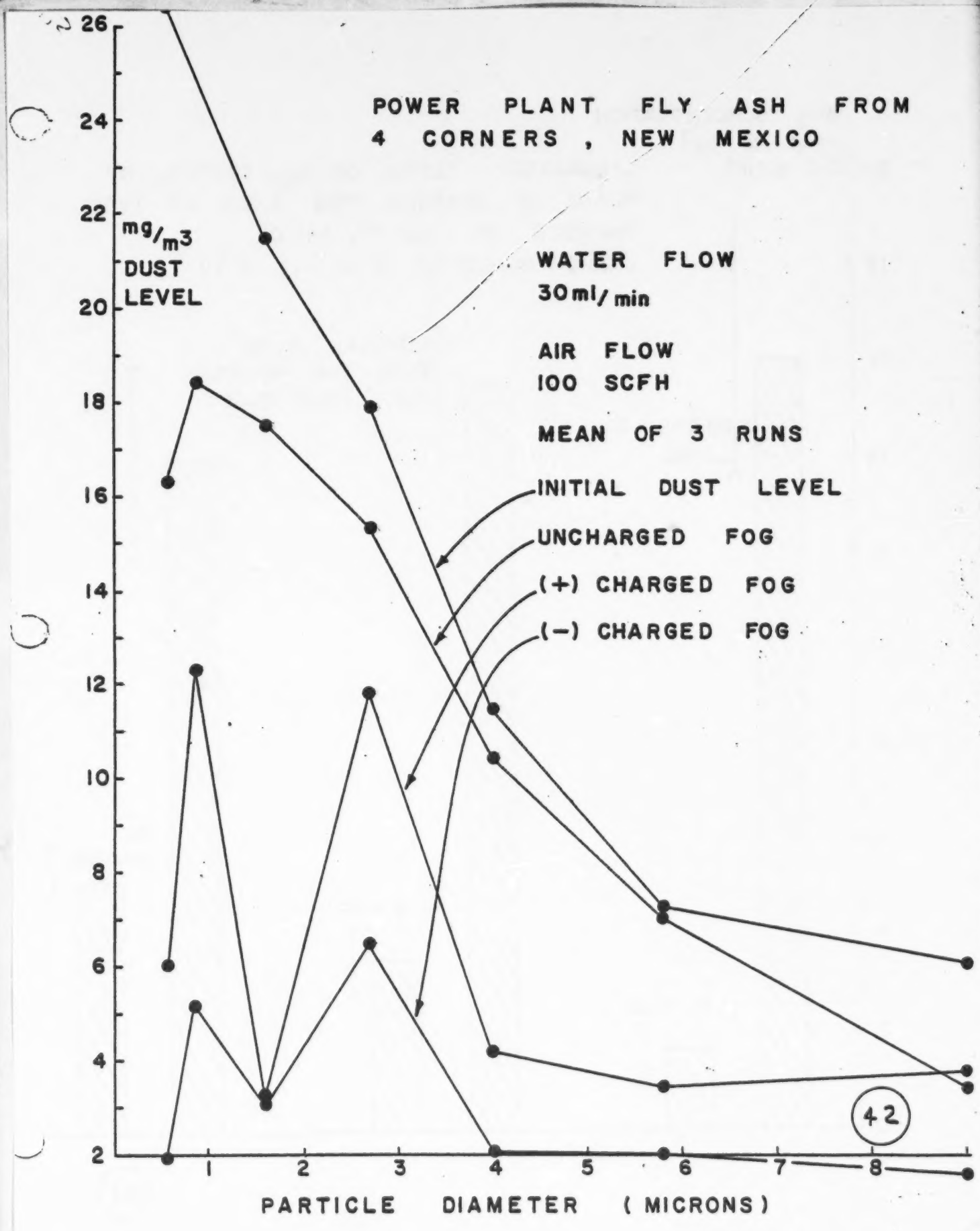


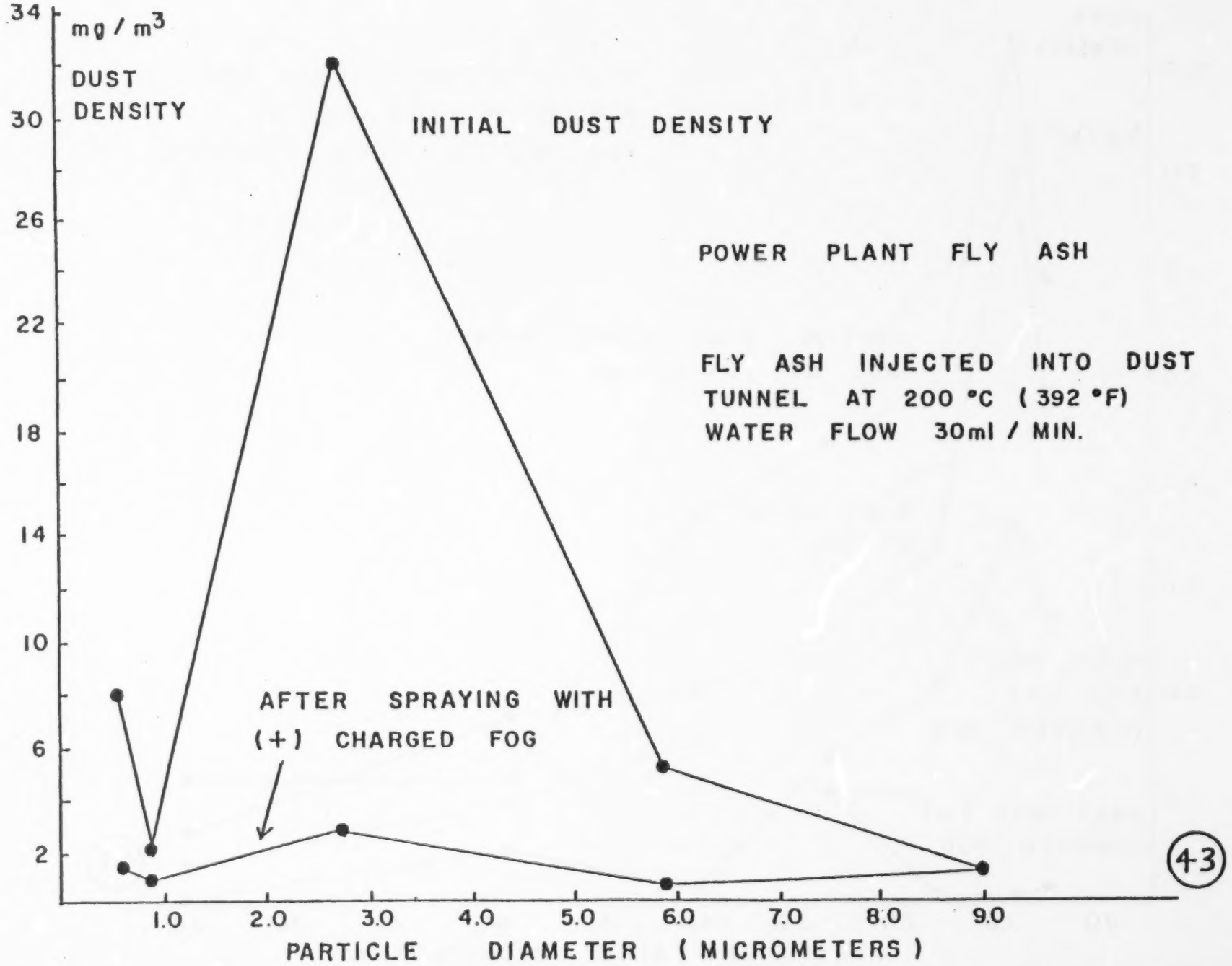
SO_2 LEVEL WITH AND WITHOUT CHARGED FOG,
FOG WATER FLOW 30 ml / min.

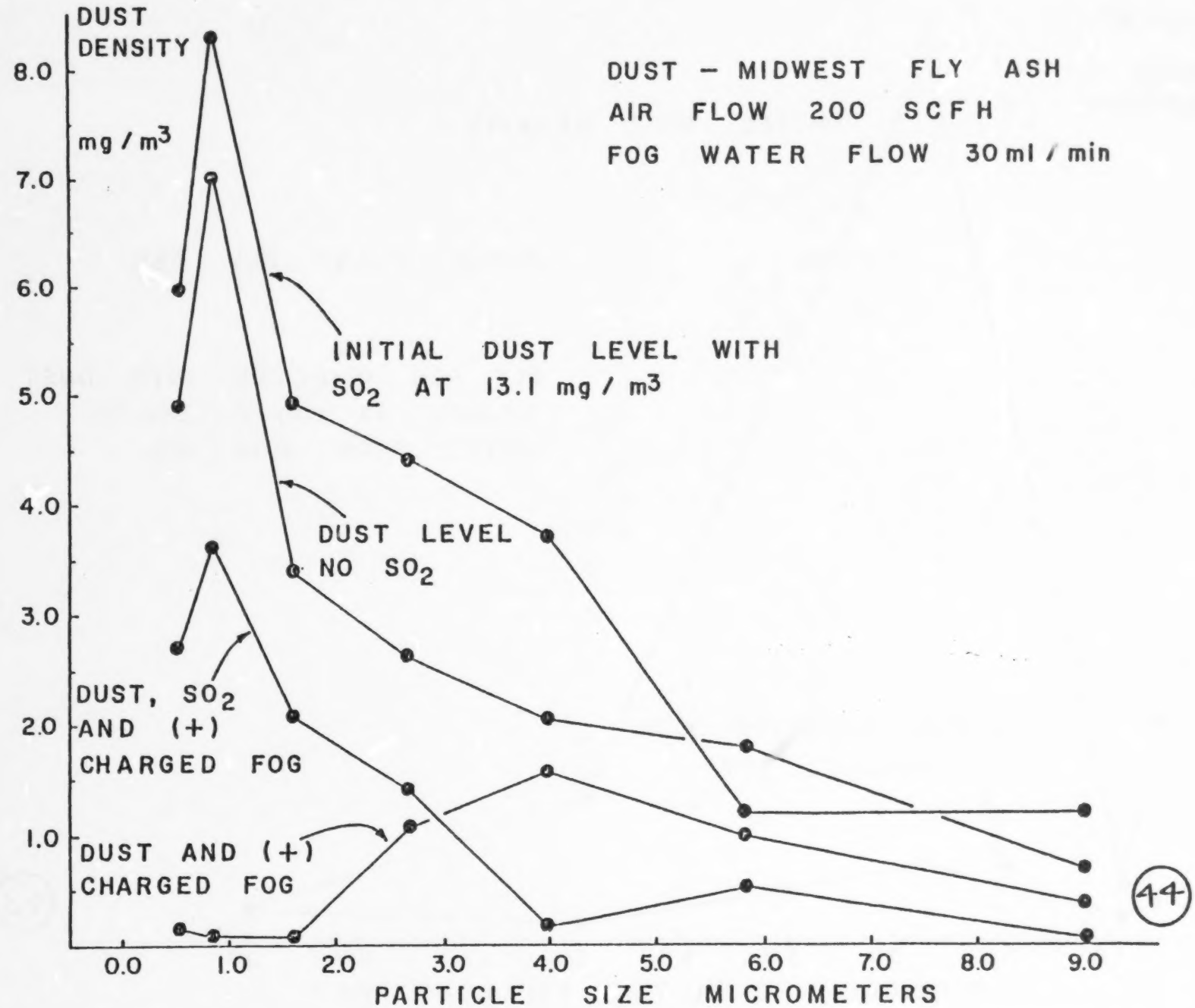


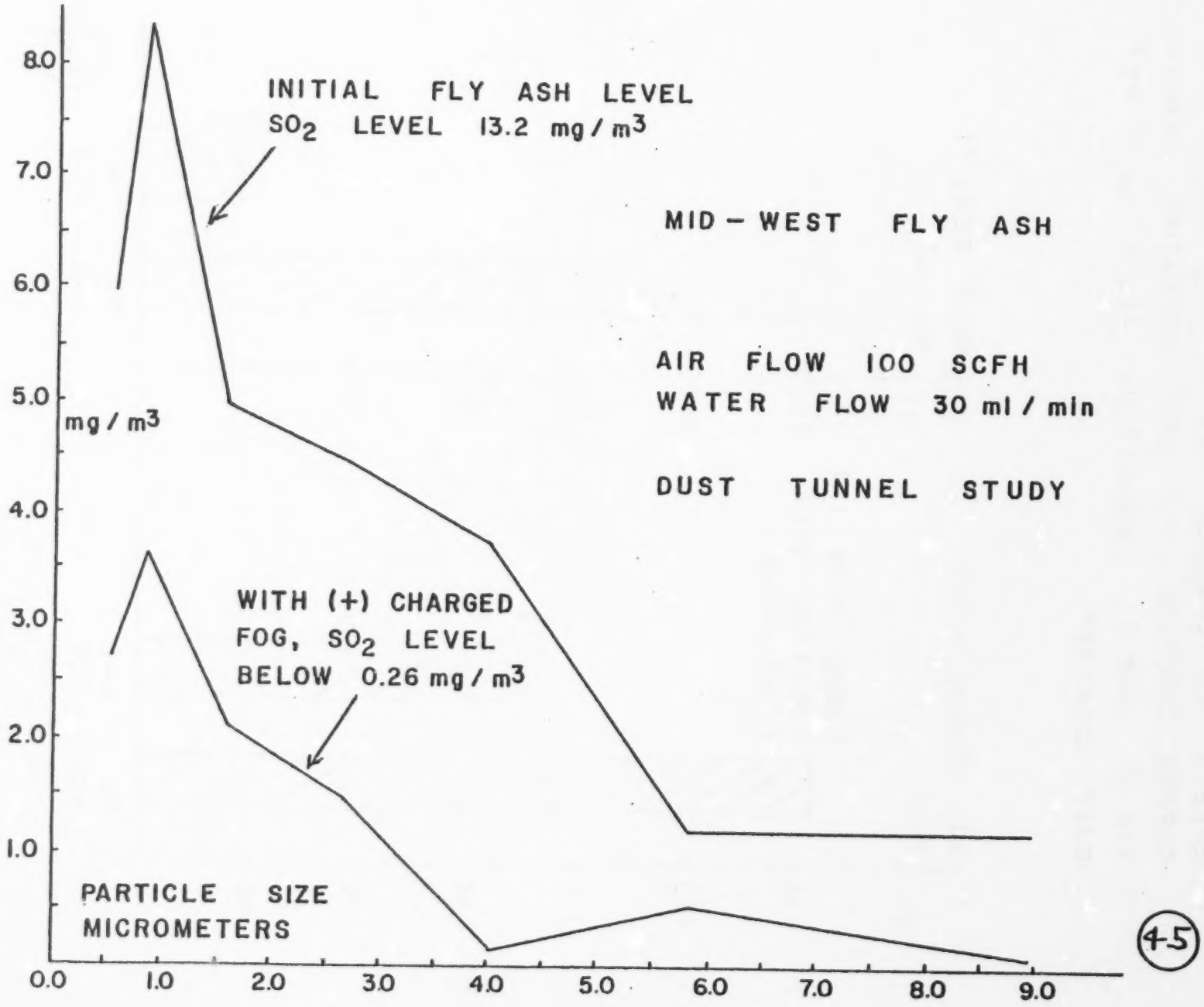
SULFUR DIOXIDE / DUST EXPERIMENTAL SYSTEM


SO_2 CONCENTRATION
PPM X 10^2
5.3 g/m3
20
18
16
14
12
10
8
6
4
2
0
LABORATORY TESTS OF SO_2 CONTROL BY MEANS OF CHARGED FOG 0.028 m^3 TEST CHAMBER AT 700 F°, 381 C°
LIQUID INJECTION 3 ml AT 6 kV
VERTICAL BARS SHOW THE SCATTER OVER FOUR RUNS
INITIAL SO_2 LEVEL
(+) FOG
(−) FOG
NO CHARGE

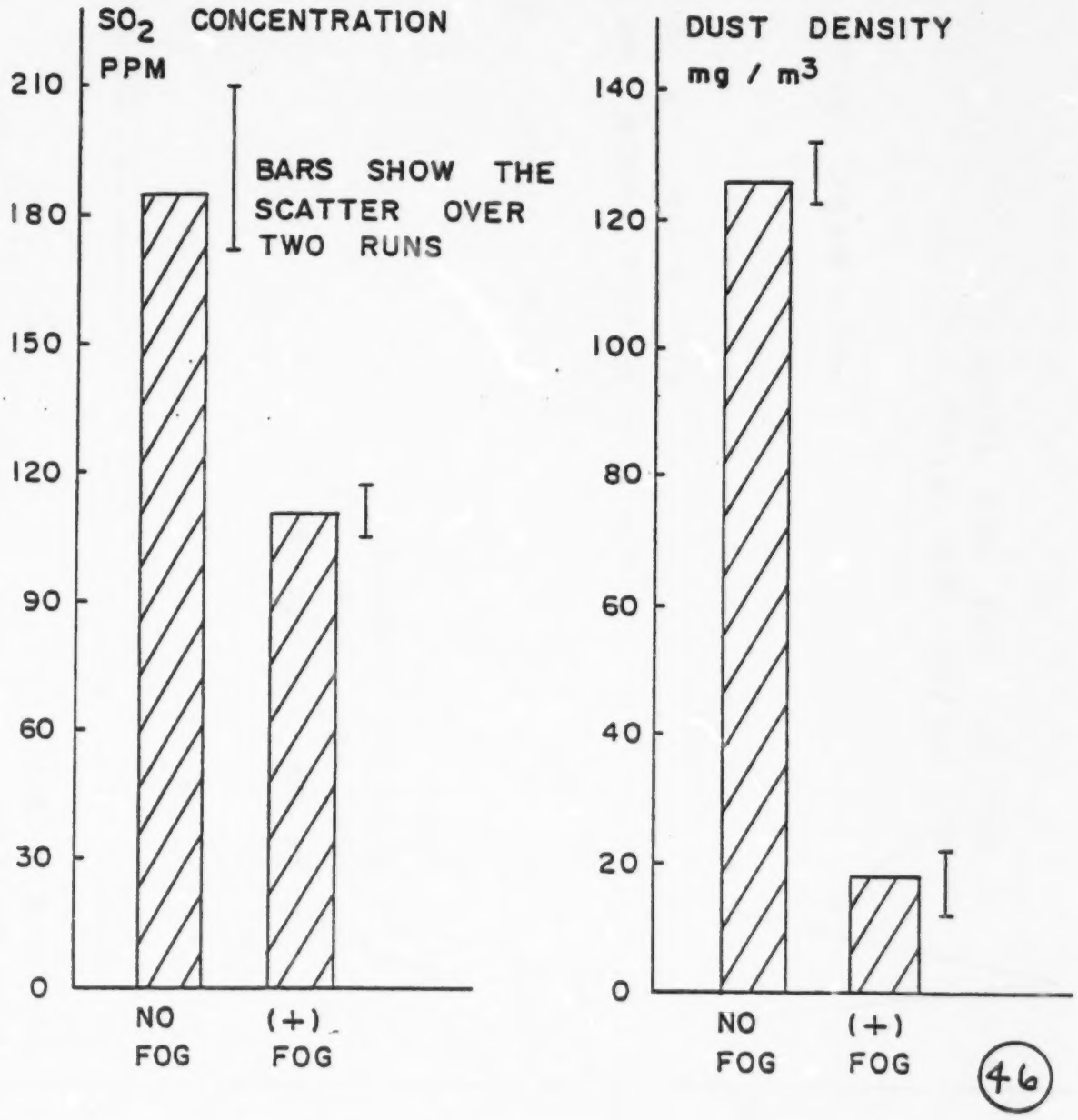

POWER PLANT FLY ASH FROM
4 CORNERS , NEW MEXICO
WATER FLOW
30 ml/ min
AIR FLOW
100 SCFH
MEAN OF 3 RUNS
INITIAL DUST LEVEL
UNCHARGED FOG
(+) CHARGED FOG
(−) CHARGED FOG
mg/m3
DUST
LEVEL
26
24
22
20
18
16
14
12
10
8
6
4
2
1
2
3
4
5
6
7
8
PARTICLE DIAMETER (MICRONS)
42

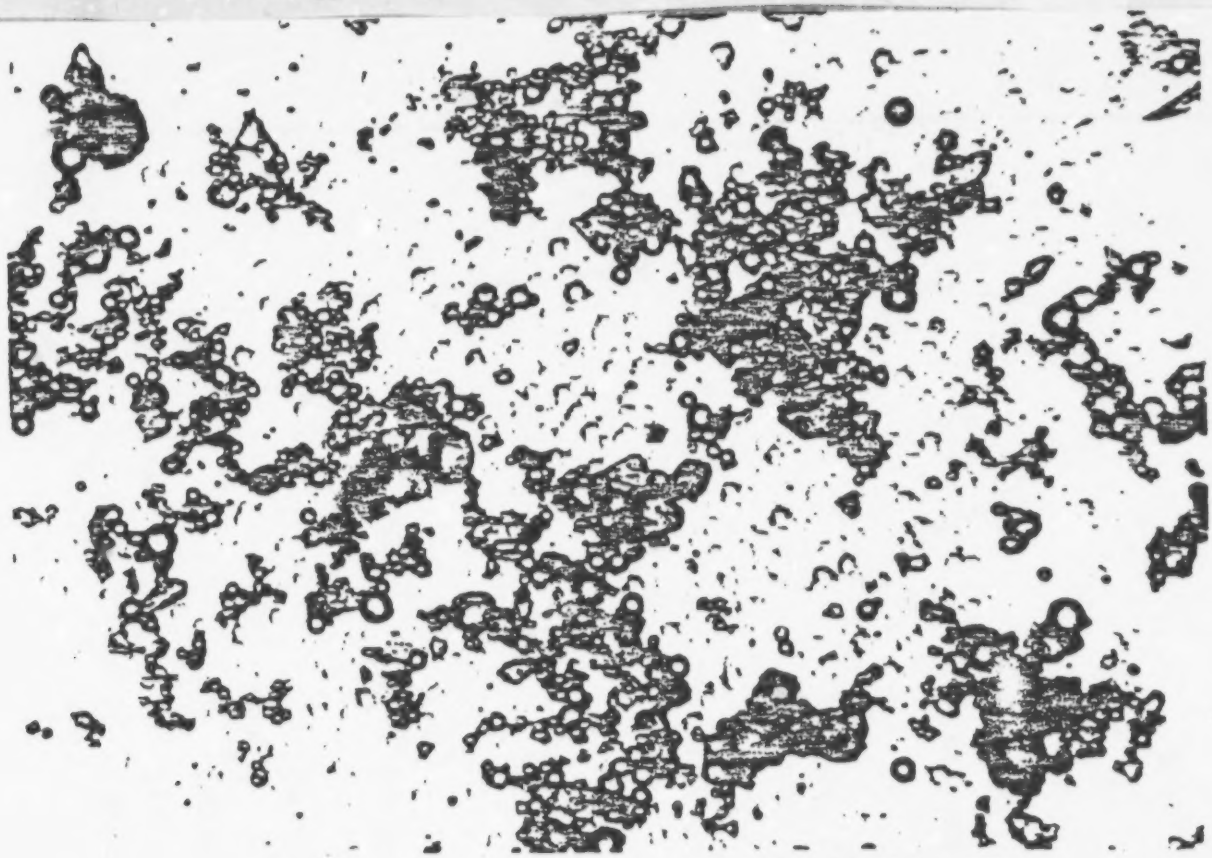

34
mg / m3
DUST
DENSITY
30
26
22
18
14
10
6
2
INITIAL DUST DENSITY
POWER PLANT FLY ASH
FLY ASH INJECTED INTO DUST
TUNNEL AT 200 °C (392 °F)
WATER FLOW 30ml / MIN.
AFTER SPRAYING WITH
(+) CHARGED FOG
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
PARTICLE DIAMETER (MICROMETERS)


DUST
DENSITY
mg / m3
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
DUST - MIDWEST FLY ASH
AIR FLOW 200 SCFH
FOG WATER FLOW 30 ml / min
INITIAL DUST LEVEL WITH
SO2 AT 13.1 mg / m3
DUST LEVEL
NO SO2
DUST, SO2
AND (+)
CHARGED FOG
DUST AND (+)
CHARGED FOG
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
PARTICLE SIZE MICROMETERS

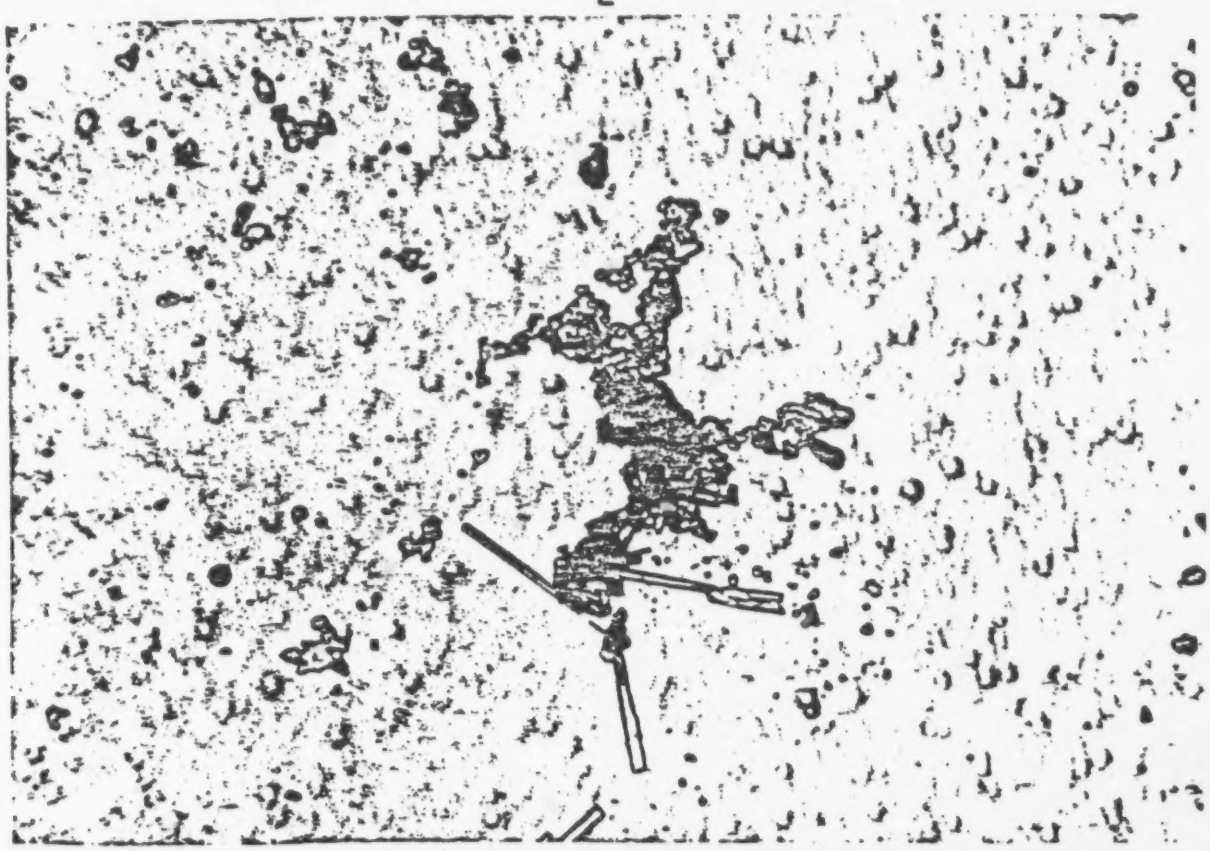

8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
mg / m3
INITIAL FLY ASH LEVEL
SO2 LEVEL 13.2 mg / m3
MID – WEST FLY ASH
AIR FLOW 100 SCFH
WATER FLOW 30 ml / min
DUST TUNNEL STUDY
WITH (+) CHARGED
FOG, SO2 LEVEL
BELOW 0.26 mg / m3
PARTICLE SIZE
MICROMETERS
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0

EFFECT OF CHARGED FOG ON SO_2 AND COPPER COMPANY FLY ASH, OPERATING TEMPERATURE 340 C. 645 F, LABORATORY TESTS IN 1 $FT.^3$ DUST CHAMBER



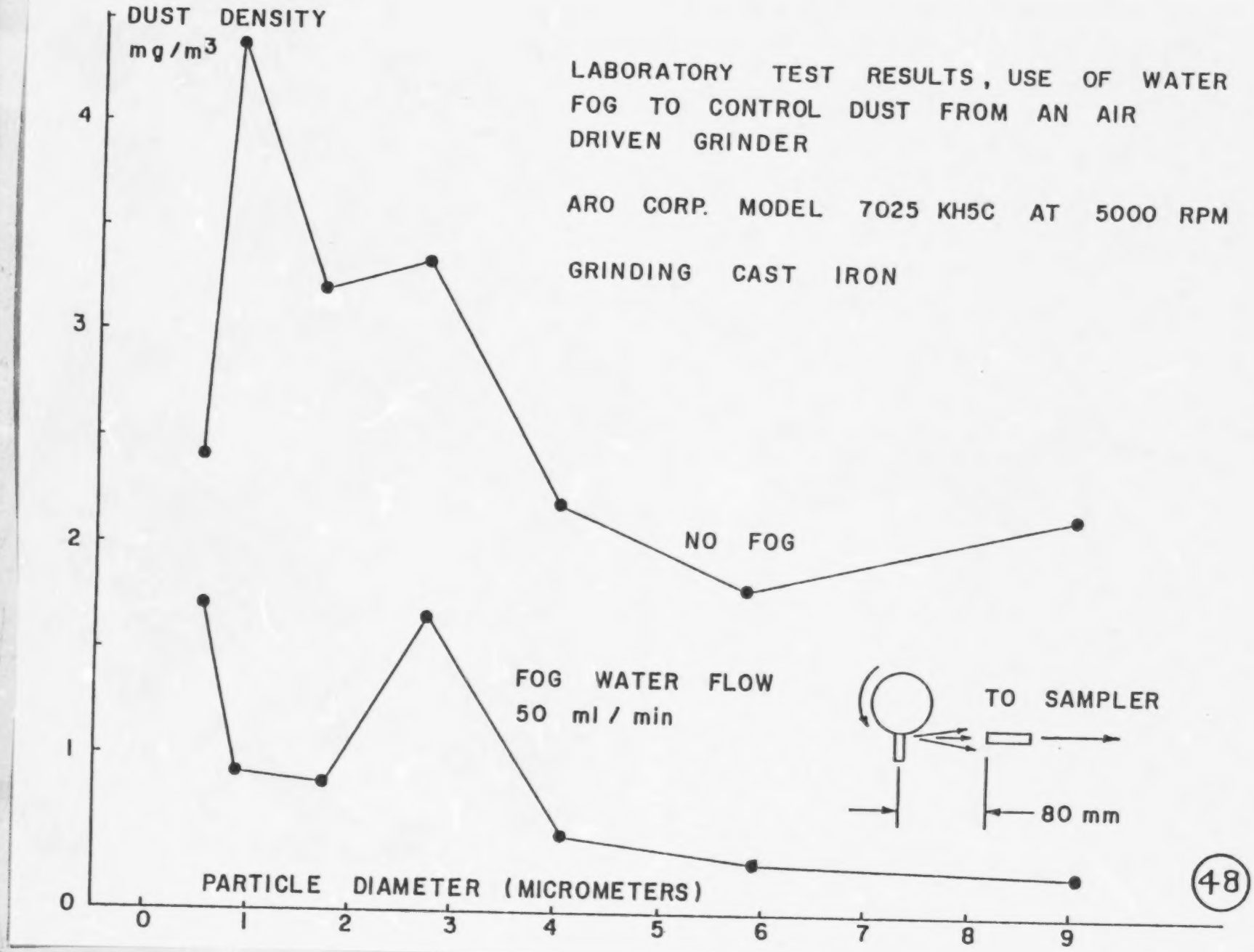


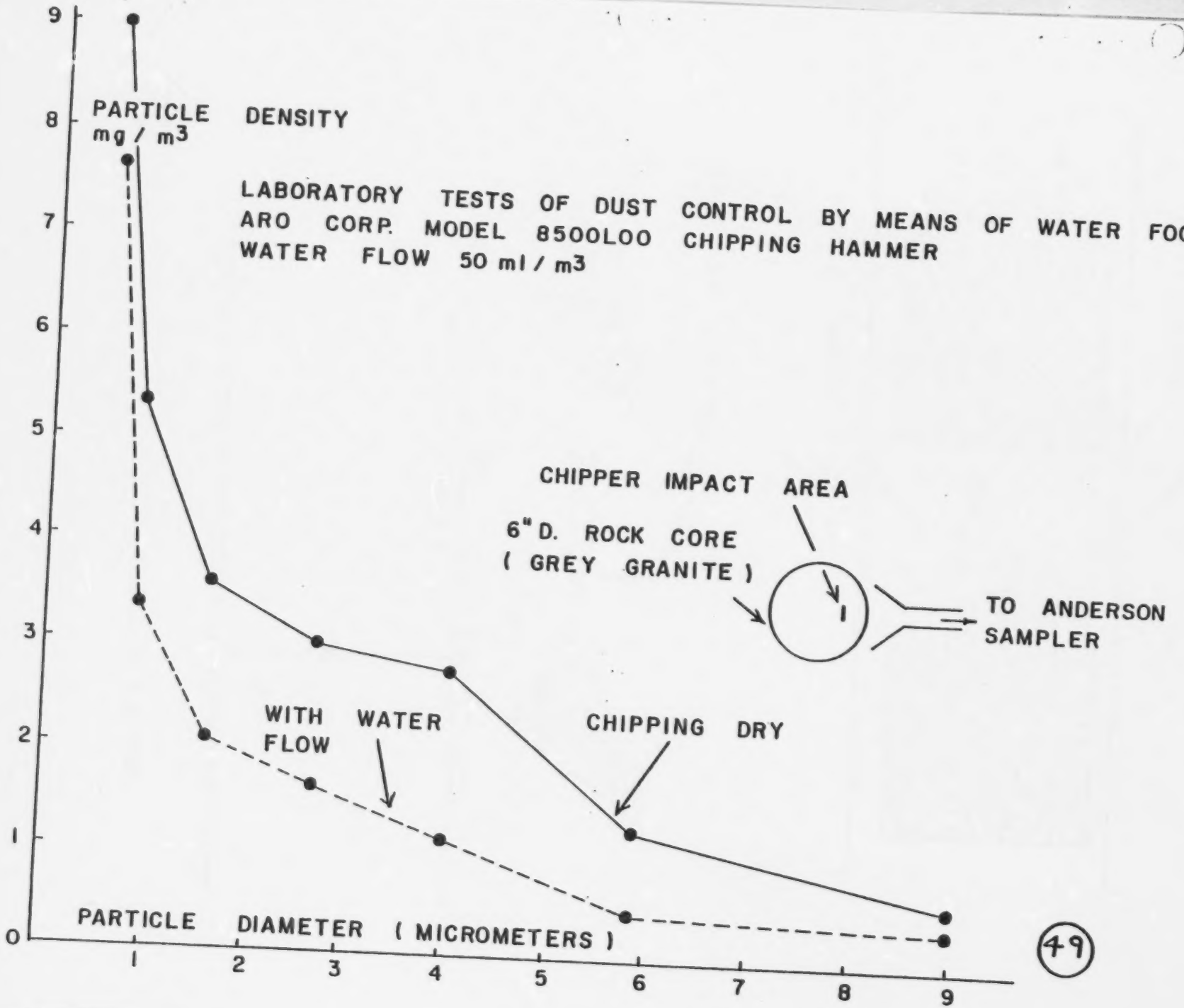
FLY ASH / SO_2 AGGLOMERATE

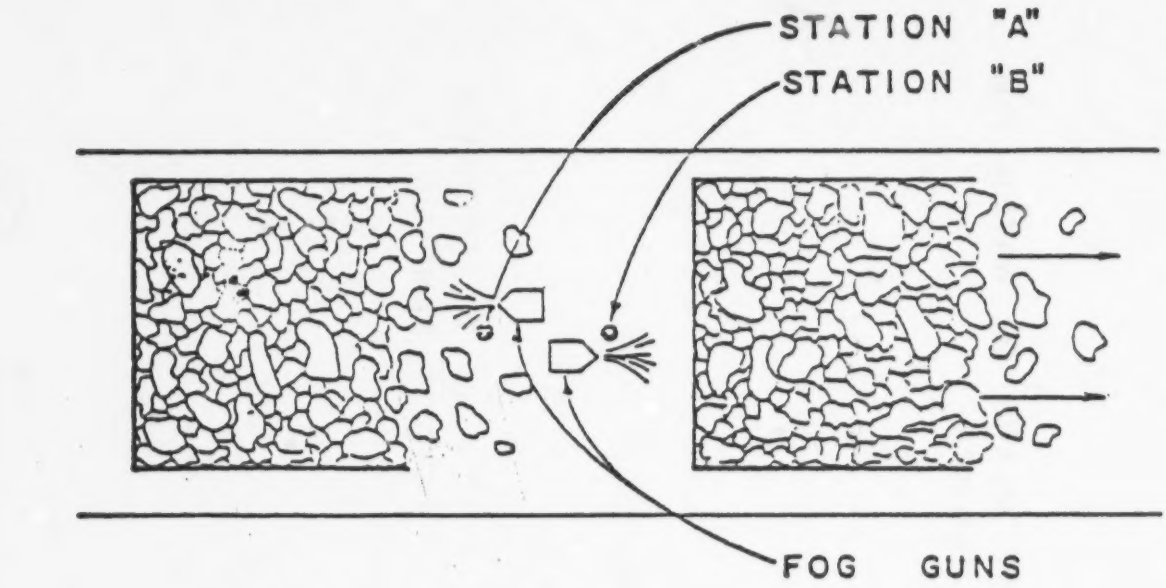


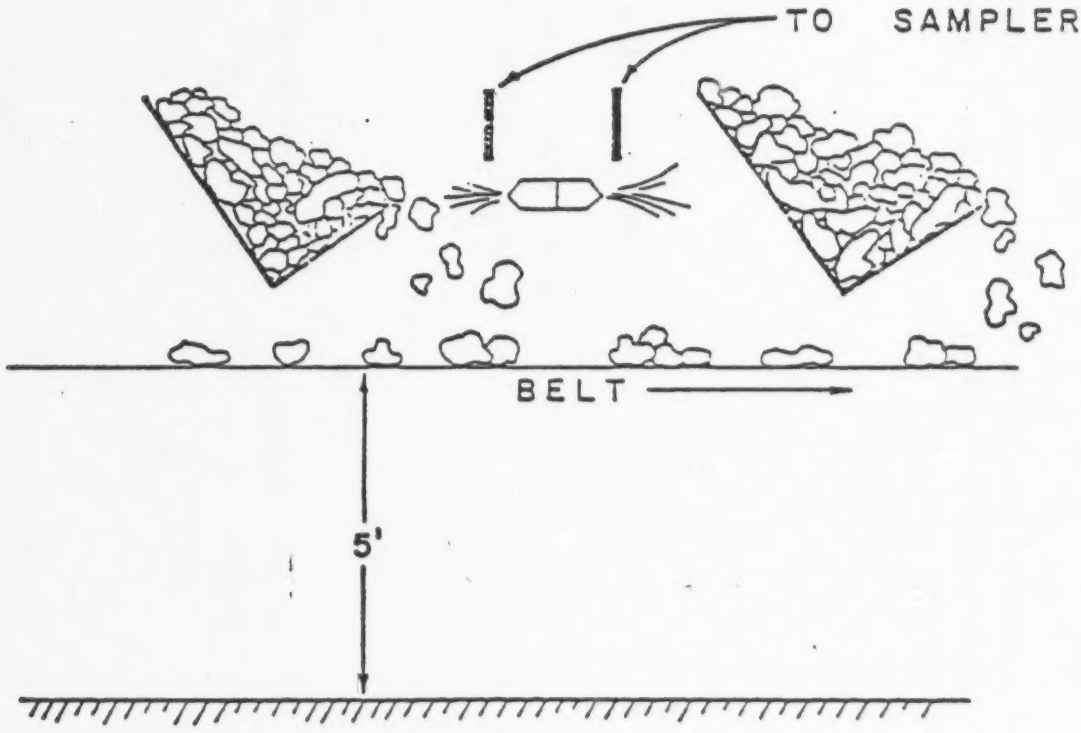
FLY ASH / SO_2 / CHARGED FOG AGGLOMERATE

30 µm

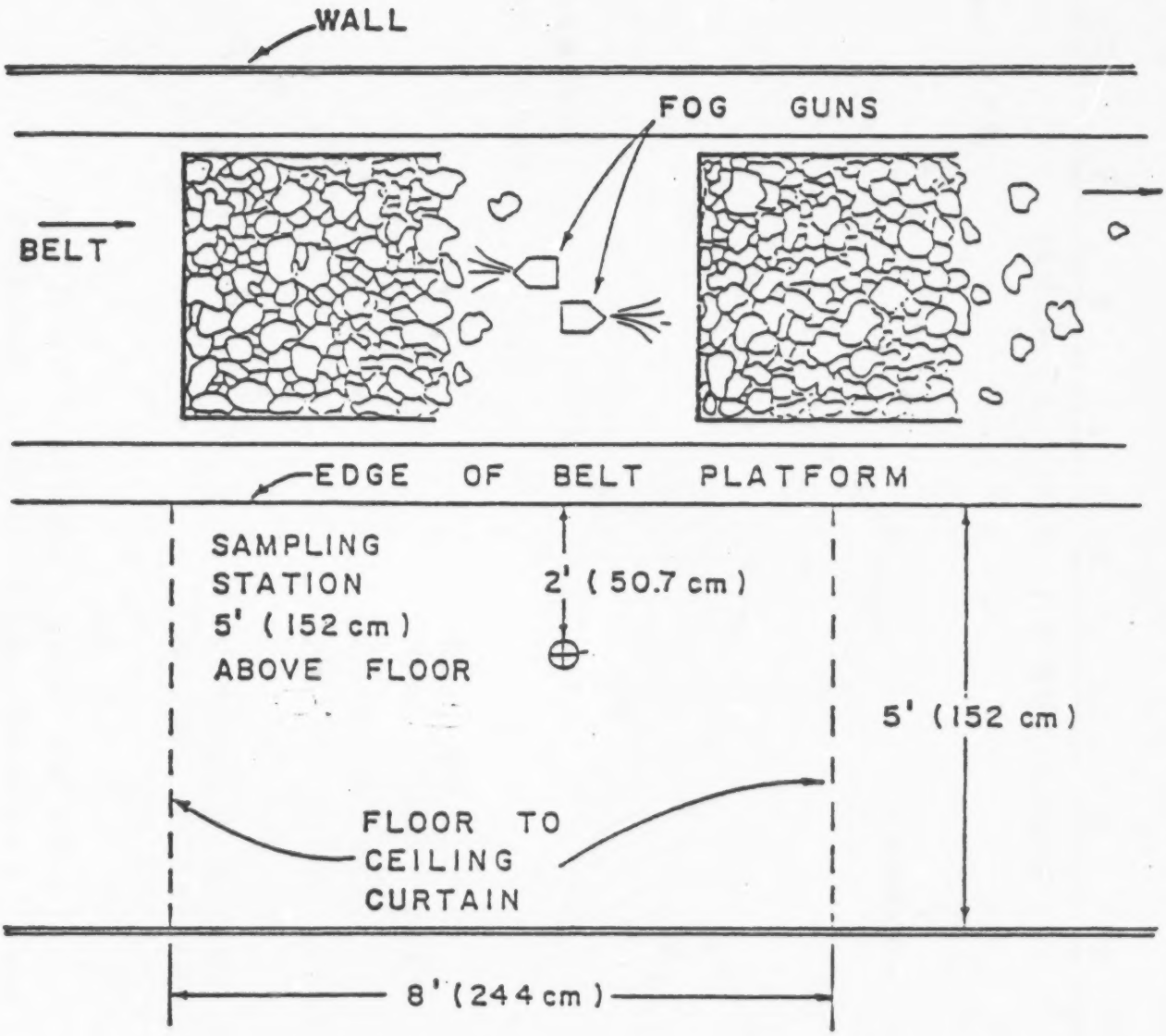

DUST DENSITY
mg/m3
4
3
2
1
0
LABORATORY TEST RESULTS, USE OF WATER FOG TO CONTROL DUST FROM AN AIR DRIVEN GRINDER
ARO CORP. MODEL 7025 KH5C AT 5000 RPM
GRINDING CAST IRON
NO FOG
FOG WATER FLOW
50 ml / min
TO SAMPLER
80 mm
PARTICLE DIAMETER (MICROMETERS)
0
1
2
3
4
5
6
7
8
9


PARTICLE DENSITY
mg / m3
LABORATORY TESTS OF DUST CONTROL BY MEANS OF WATER FOG
ARO CORP. MODEL 8500LOO CHIPPING HAMMER
WATER FLOW 50 ml / m3
CHIPPER IMPACT AREA
6" D. ROCK CORE
(GREY GRANITE)
TO ANDERSON SAMPLER
WITH WATER FLOW
CHIPPING DRY
PARTICLE DIAMETER (MICROMETERS)
0
1
2
3
4
5
6
7
8
9



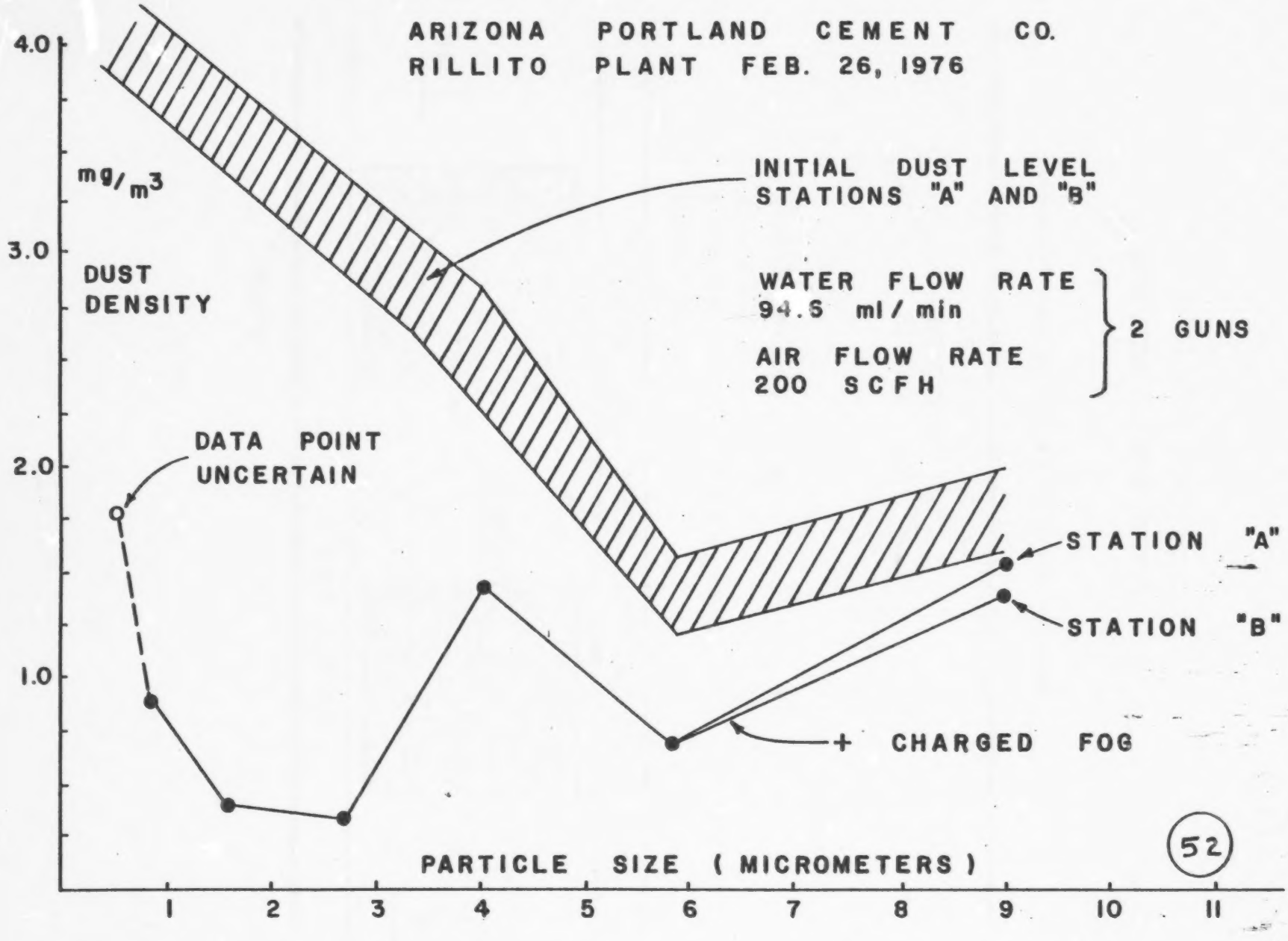


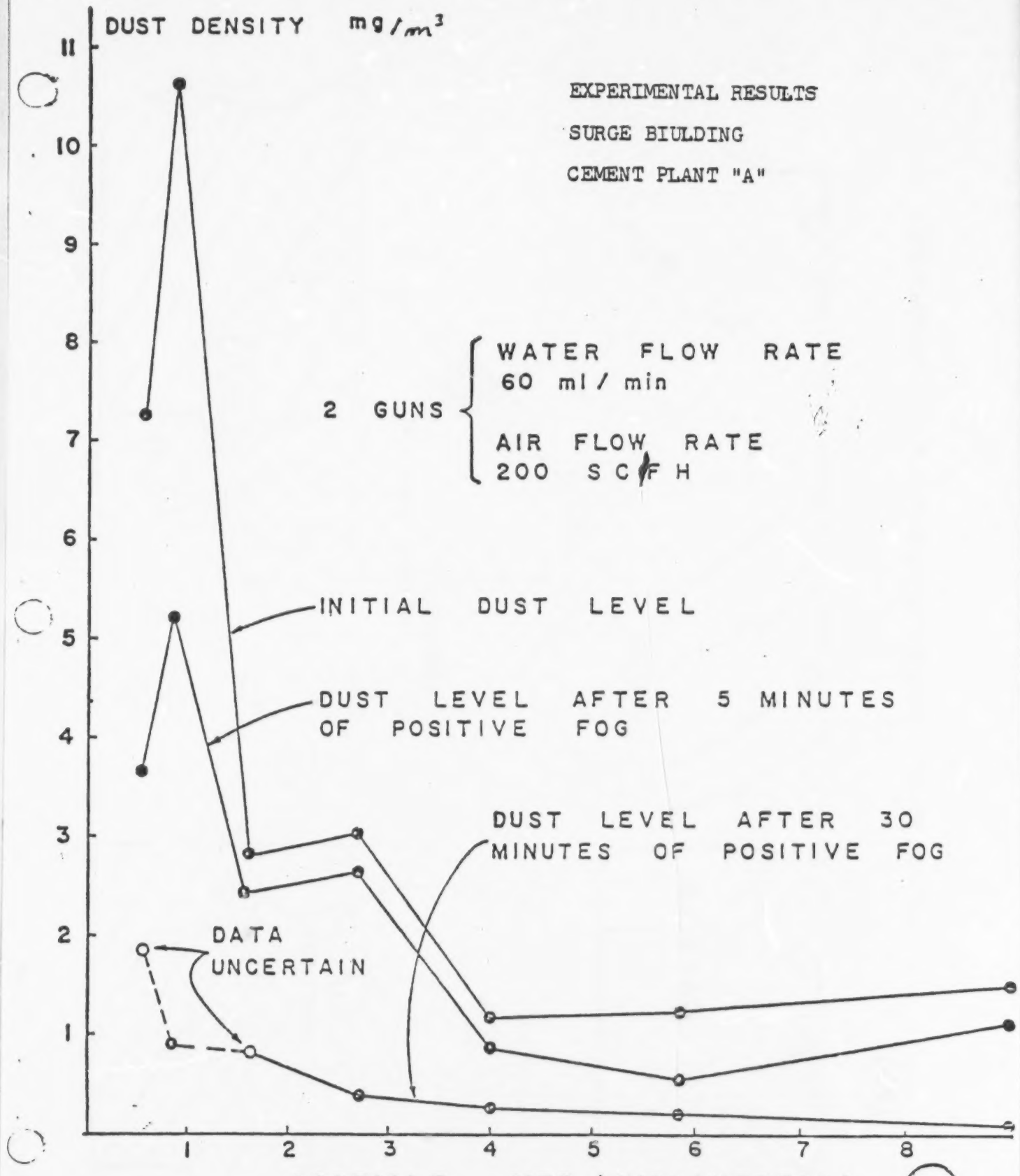
TEST SET UP CEMENT PLANT "A"

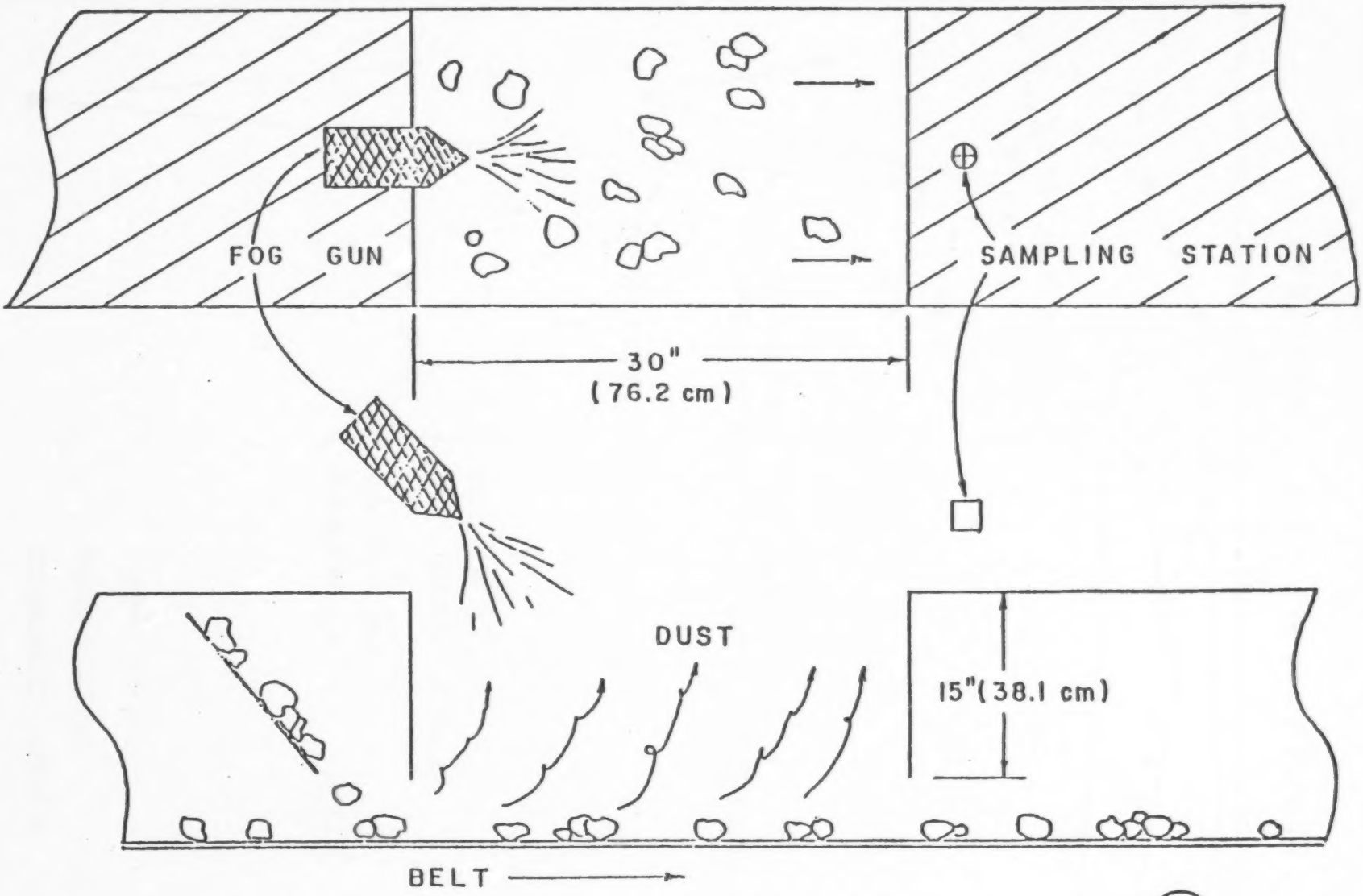


PLAN VIEW OF SURGE BUILDING

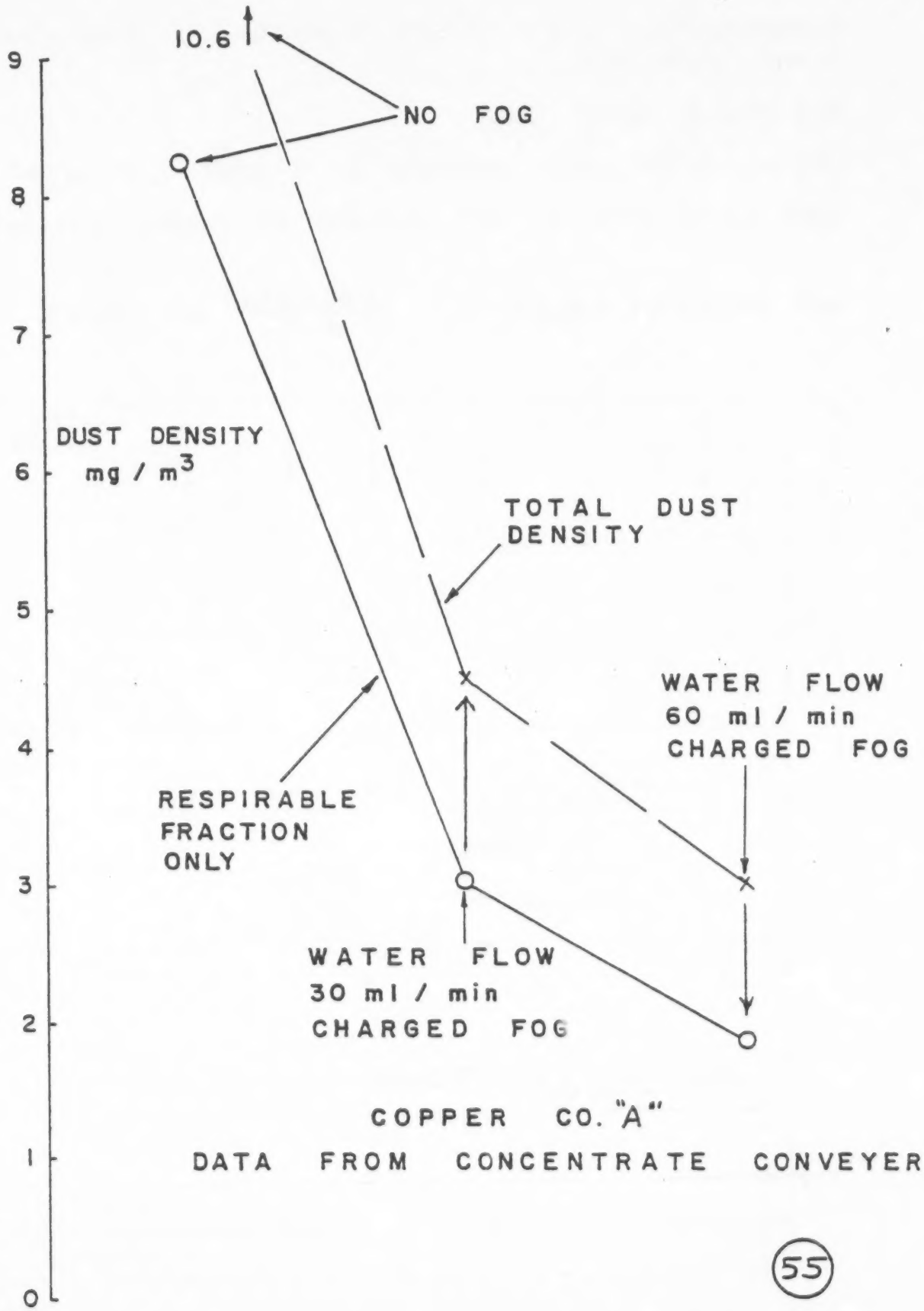
CEMENT PLANT "A"


ARIZONA PORTLAND CEMENT CO.
RILLITO PLANT FEB. 26, 1976
4.0
3.0
2.0
1.0
mg/m3
DUST DENSITY
INITIAL DUST LEVEL
STATIONS "A" AND "B"
WATER FLOW RATE
94.5 ml/min
AIR FLOW RATE
200 SCFH
2 GUNS
DATA POINT
UNCERTAIN
STATION "A"
STATION "B"
+ CHARGED FOG
PARTICLE SIZE (MICROMETERS)
1
2
3
4
5
6
7
8
9
10
11


DUST DENSITY mg/m³
EXPERIMENTAL RESULTS
SURGE BIULDING
CEMENT PLANT "A"
2 GUNS
WATER FLOW RATE
60 ml / min
AIR FLOW RATE
200 S C F H
INITIAL DUST LEVEL
DUST LEVEL AFTER 5 MINUTES OF POSITIVE FOG
DUST LEVEL AFTER 30 MINUTES OF POSITIVE FOG
DATA UNCERTAIN
11
10
9
8
7
6
5
4
3
2
1
1
2
3
4
5
6
7
8
PARTICLE SIZE (MICROMETERS)



EXPERIMENTAL SET-UP CONCENTRATE CONVEYOR COPPER COMPANY "A"



COPPER CO. "A"

DATA FROM CONCENTRATE CONVEYER

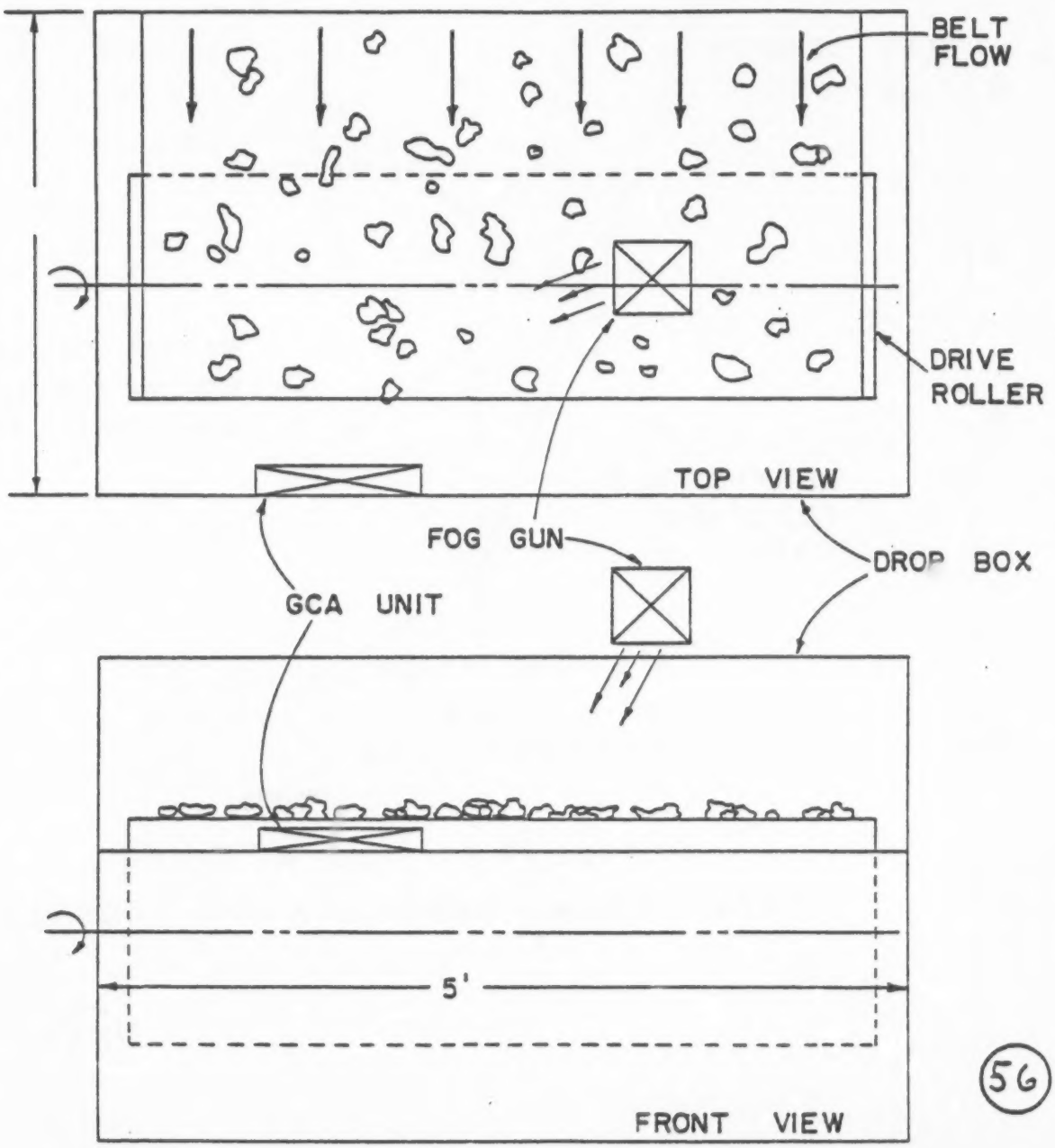
EXPERIMENTAL STUDY COPPER COMPANY "A" CONCENTRATE PLANT DROP BOX

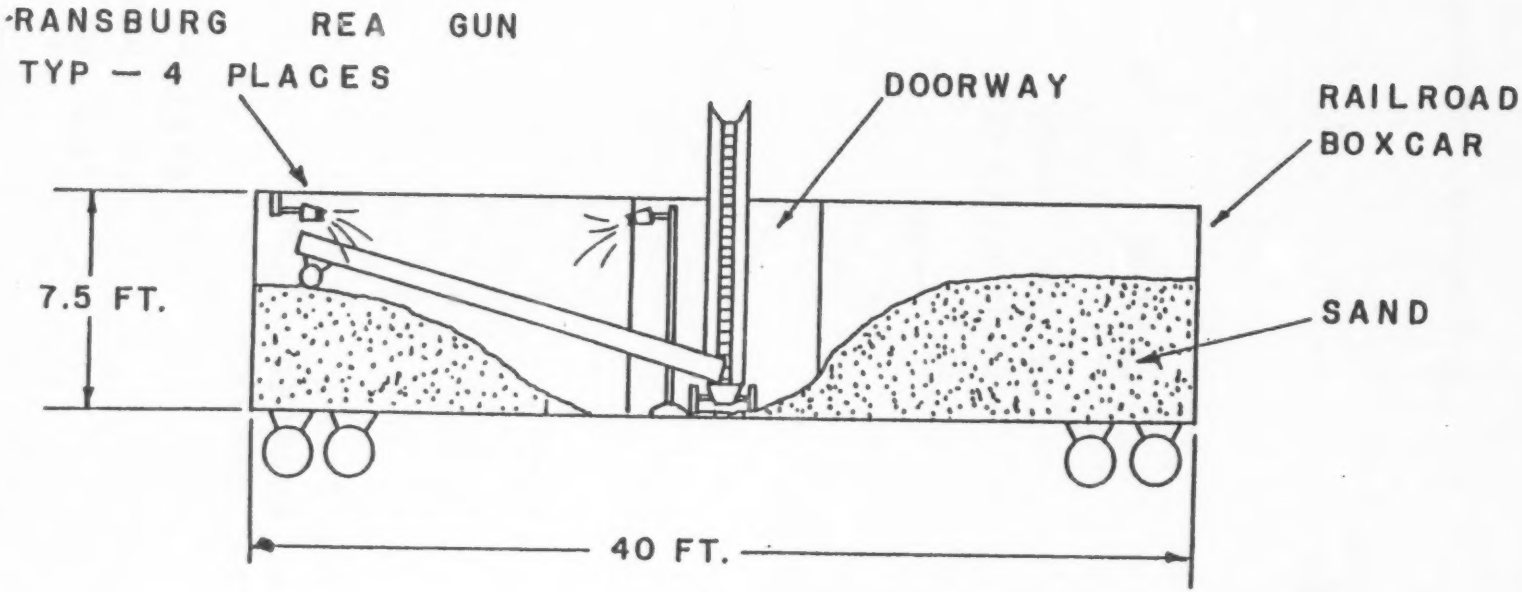
RESPIRABLE DUST ONLY

INITIAL DUST LEVEL AVERAGE OF 11 RUNS 6.95 mg/m^3

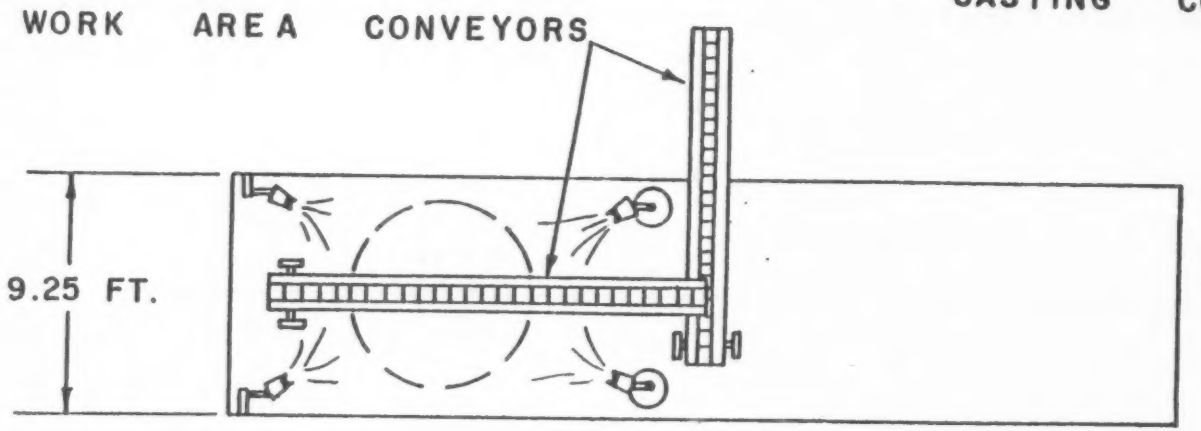
DUST LEVEL WITH (+) FOG AVERAGE OF 7 RUNS 2.45 mg/m^3

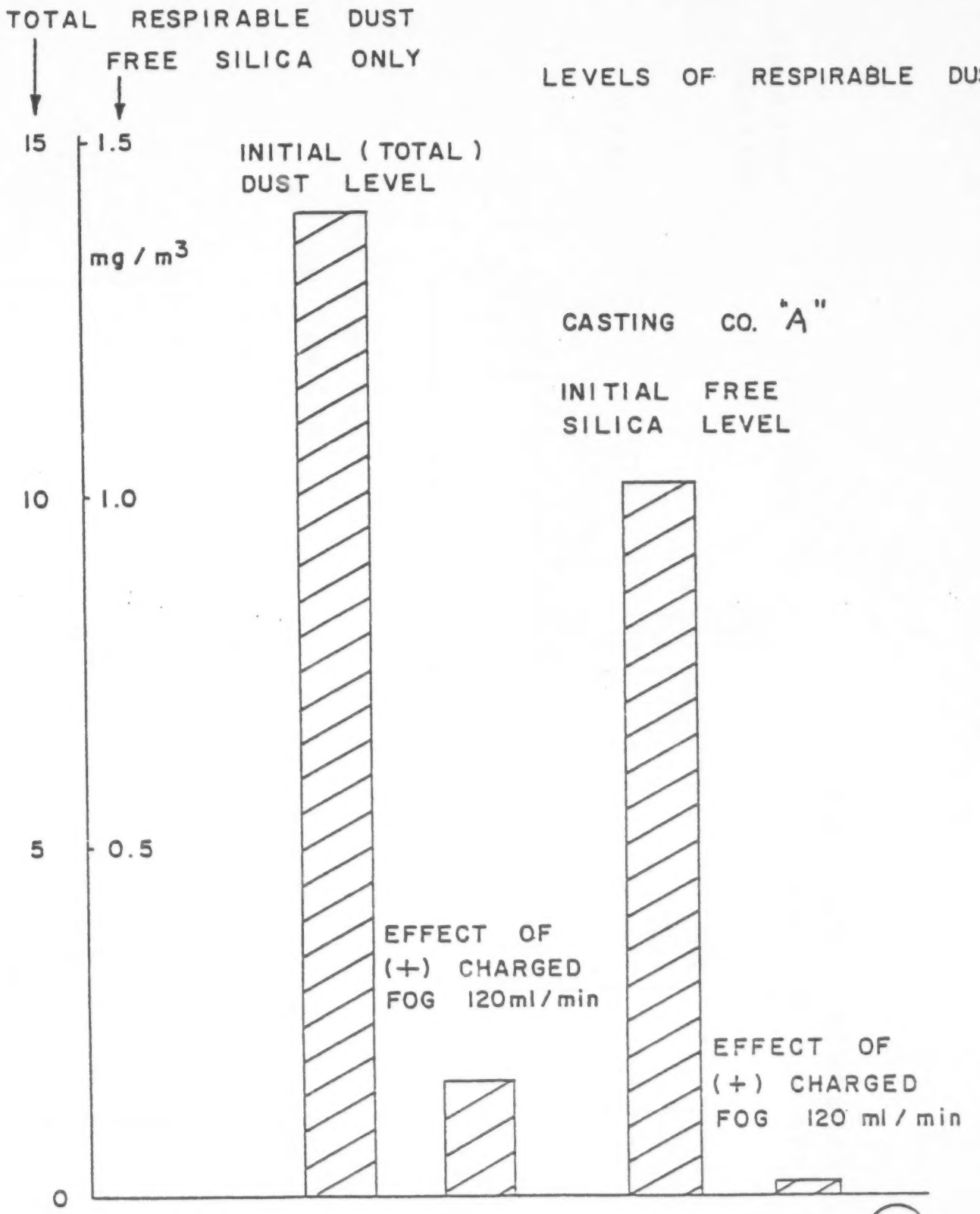
NET REDUCTION — 65.4 % $\quad \frac{6.95-2.45}{6.95}\ 100 = 65.4\ \%$

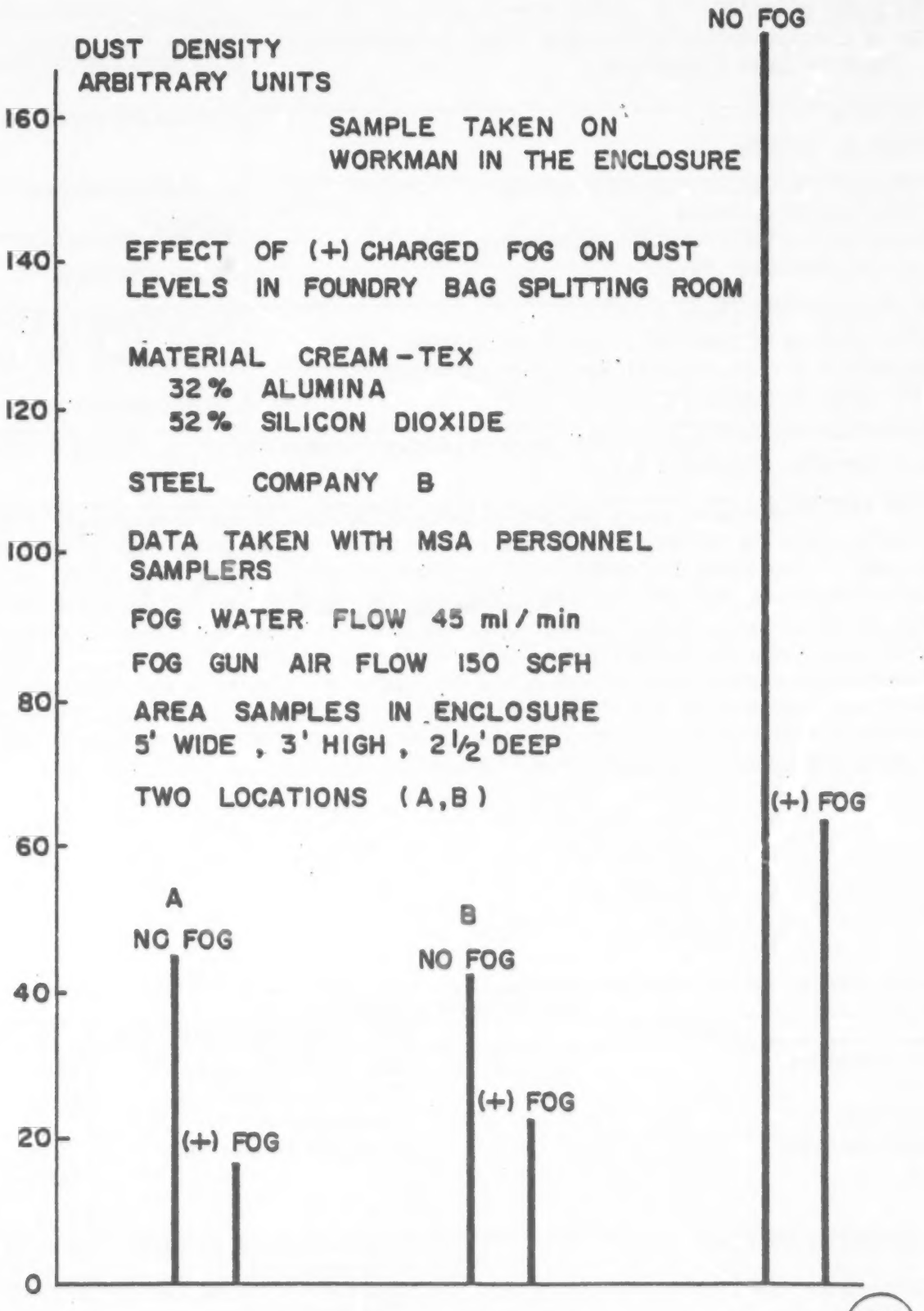




TEST SET-UP AT
CASTING CO. A




TOTAL RESPIRABLE DUST
FREE SILICA ONLY
LEVELS OF RESPIRABLE DUST
15
1.5
INITIAL (TOTAL)
DUST LEVEL
mg / m3
CASTING CO. "A"
INITIAL FREE
SILICA LEVEL
10
1.0
5
0.5
EFFECT OF
(+) CHARGED
FOG 120ml / min
EFFECT OF
(+) CHARGED
FOG 120 ml / min
0


DUST DENSITY
ARBITRARY UNITS
160
140
120
100
80
60
40
20
0
SAMPLE TAKEN ON WORKMAN IN THE ENCLOSURE
EFFECT OF (+) CHARGED FOG ON DUST LEVELS IN FOUNDRY BAG SPLITTING ROOM
MATERIAL CREAM-TEX
32% ALUMINA
52% SILICON DIOXIDE
STEEL COMPANY B
DATA TAKEN WITH MSA PERSONNEL SAMPLERS
FOG WATER FLOW 45 ml/min
FOG GUN AIR FLOW 150 SCFH
AREA SAMPLES IN ENCLOSURE
5' WIDE, 3' HIGH, 2 1/2' DEEP
TWO LOCATIONS (A,B)
A
NO FOG
(+) FOG
B
NO FOG
(+) FOG
NO FOG
(+) FOG